FORTY-FIFTH ANNUAL REPORT

For 1925-26

OHIO
Agricultural Experiment Station

WOOSTER, OHIO, U. S. A., FEBRUARY, 1927

BULLETIN 402

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Forty-Fifth Annual Report

OF THE

Ohio Agricultural Experiment Station

For the Year ended June 30, 1926

Published by the order of the State Legislature

WOOSTER, OHIO
EXPERIMENT STATION PRESS
1927

HON. A. V. DONAHEY,
Governor of Ohio:

SIR: I have the honor to present herewith the forty-fifth annual report of the Ohio Agricultural Experiment Station for the year ended June 30, 1926.

C. G. WILLIAMS,
Director

OHIO AGRICULTURAL EXPERIMENT STATION

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A. G. NEWHALL, M. S.	Assistant
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PAUL E. TILFORD, M. S.	Assistant
J. D. WILSON, Ph. D.	Assistant

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G. F. Henning, M. S. ..... Assistant (Columbus)
E. K. Jackson, B. A. ..... Assistant (Columbus)
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C. G. McBride, M. S. ..... Assistant (Columbus)
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E. C. Newcomer ..... Assistant (Columbus)

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P. B. Potter, B. S. ..... Assistant (Columbus)
E. A. Silver, B. S. ..... Assistant (Columbus)
B. M. Stahl, M. S. ..... Assistant (Columbus)

ENTOMOLOGY

J. S. Houser, M. S. A. ..... Chief
L. L. Hubbe, Ph. D. ..... Associate
Herbert Osborn, D. Sc.[1] ..... Associate (Columbus)
C. R. Cutright, Ph. D. ..... Assistant
G. A. Filinger, M. S. ..... Assistant
H. L. Gui, M. S. ..... Assistant
E. G. Kelsheimer, M. S. ..... Assistant
C. R. Neiswander, Ph. D. ..... Assistant
J. B. Polivka, M. S. ..... Assistant

FORESTRY

Edmund Secrest, B. S. ..... Chief and Asso. Dir. of Sta. (State Forester)
J. J. Crumley, Ph. D. ..... Associate (Athens)
O. A. Alderman, M. F. ..... Assistant
F. W. Dean, B. S. ..... Assistant (Extension Forester)
B. E. Leete, M. F. ..... Assistant (Portsmouth)
L. J. Leffelman, M. F. ..... Assistant
G. C. Martin ..... Superintendent State Nursery (Marietta)
Scott Harry ..... In charge Arboretum
John Withers ..... Ranger Waterloo State Forest
Carlos Graham ..... Ranger Shawnee State Forest
William Debolt ..... Ranger Scioto State Forest

HOME ECONOMICS

Faith R. Lanman, B. S. ..... Chief (Columbus)
Mary Anne Brown, B. S. ..... Assistant (Columbus)
Hughina McKay, M. A. ..... Assistant (Columbus)
Elsie Steiger, B. S. ..... Assistant (Columbus)

HORTICULTURE

J. H. Gourley, M. S. ..... Chief
F. H. Ballou ..... Associate (Newark)
John Bushnell, Ph. D. ..... Assistant
Donald Comin, B. S. ..... Assistant
C. W. Ellenwood ..... Assistant
F. S. Howlett, Ph. D. ..... Assistant
I. P. Lewis, B. S. ..... Assistant (Marietta)
Roy Magruder, B. S. ..... Assistant
J. S. Shoemaker, Ph. D. ..... Assistant
Ora Flack ..... Foreman of Orchards
C. G. Laper ..... Foreman of Greenhouses
G. R. Mann ..... Florist
O. N. Riley ..... Foreman Washington Co. Truck Farm

MISCELLANEOUS

W. H. Alexander[2] ..... Climatologist (Columbus)
William H. Kramer ..... Bursar
W. K. Greenbank ..... Editor
Sarah Painter, A. B. ..... Librarian
W. J. Holmes ..... Printer
Dora Ellis ..... Mailing Clerk
M. S. Dawson ..... Photographer
Glenn Hall ..... Engineer

DISTRICT AND COUNTY EXPERIMENT FARMS

M. A. Bachtell, B. S. ..... In Charge
S. C. Hartman, M. S. ..... Supt. Southeastern Test and Washington Co. Farms, Carpenter
Henry M. Wachter ..... Supt. Southwestern Test Farm, Germantown
J. T. Wilson ..... Supt. Northeastern Test Farm, Strongsville
C. H. Crawford, B. S. ..... Supt. Trumbull Co. Expt. Farm, Cortland
H. R. Hoyt ..... Supt. Paulding Co. Expt. Farm, Wooster
Walter Mahan ..... Supt. Belmont Co. Expt. Farm, St. Clairsville
H. W. Rogers ..... Supt. Madison and Miami Co. Expt. Farms, London
L. W. Sherman, B. S. ..... Supt. Mahoning Co. Expt. Farm, Canfield
W. E. Weaver ..... Supt. Clermont and Hamilton Co. Expt. Farms, Mt. Healthy

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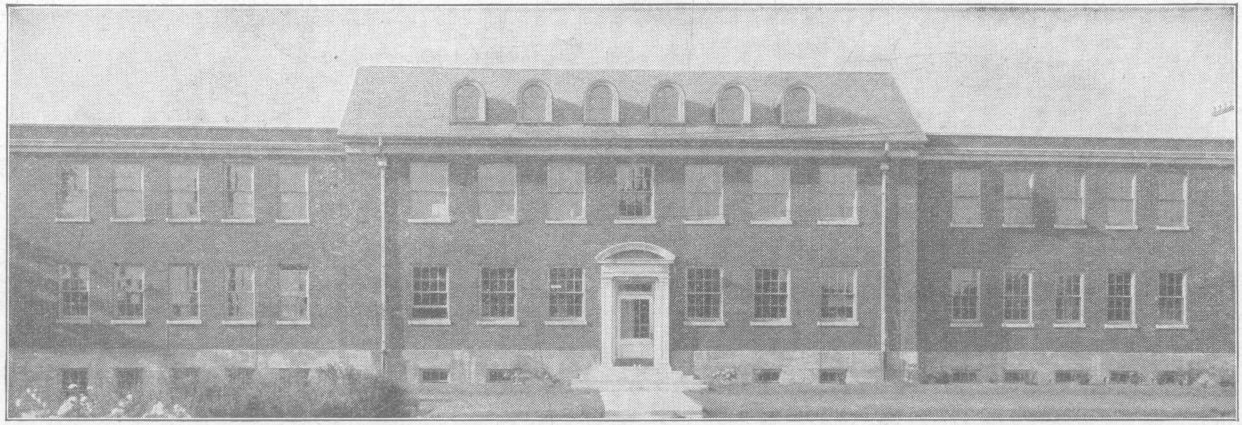
[1]In cooperation with College of Agriculture, Ohio State University.
[2]**In cooperation with the U. S. Department of Agriculture.**

CONTENTS

CONTENTS



Thorne Hall

Offices of the Departments of Agronomy, Entomology, and Plant Pathology, and the Printery

A PROGRESS REPORT OF THE DIRECTOR ON THE STATION'S WORK FOR THE YEAR ENDED JUNE 30, 1926

Two events of the past year have extended the Station's work very considerably—namely: additional appropriations from the Federal government under what is known as the Purnell Act; and the rapid extension of the area infested by the European corn borer, with a corresponding increase in the degree of infestation.

While the Purnell Act provides for work along all lines of agricultural research, it was enacted with the idea that more attention should be given to the problems of rural and home economics than heretofore. Accordingly very early in the year this Station established a department of Rural Economics, making use in large part of the excellent department of the Agricultural College of the Ohio State University. The head of the College department was made head of the Station's department of rural economics; the two institutions sharing equally in his salary. Other members of the College staff were used in research work, while several new full-time men have been added to the Station staff in rural economics work.

A little later in the year a research department of Home Economics was established in a similar manner, making large use of the department of home economics of the College. These new departments have a number of projects underway, and some were completed during the year.

The research problem necessitated by the corn borer infestation will be considered in detail in later pages of this report. While it was thought that the Legislature had made reasonable provision for this work, it became apparent before the year was over that much work should be undertaken, and the Emergency Board provided an additional appropriation of $14,000 for this purpose.

SPECIAL FIELD DAYS

During the year covered by this report the Station held special days for conference and for study of its work in field and laboratories as follows:

The annual orchard day, August 21, 1925, at which horticulturists from all sections of the State inspected its orchards, vineyards, and potato and vegetable work.

The officials and appraisers of the Ohio-Pennsylvania Joint Stock Land Bank, May 24, 1926.

The second annual vocational agricultural day, May 26, 1926, when teachers and students from most of the counties of the State were in attendance.

The annual livestock day, June 4, 1926, at which some 104 head of cattle, 142 swine, and 220 sheep, which had been on feeding tests for several months, were studied.

The annual poultry day, June 18, 1926 made a new high record attendance of 3,000 people.

Instead of a wheatfield day, as heretofore, it was thought best to give the farmers a choice of a wheatfield week of four days, which was held June 22 to 25, 1926.

A soil fertility conference of the National Fertilizer Association was held June 29, 1926.

Groups of farmers from fourteen northeastern Ohio counties held special meetings at the Station on different days during June, and college and high school groups to the number of seventeen visited the Station during May and June.

Field days for the inspection and study of the work at the district and county experiment farms and the State forests were held as follows:

Clermont County, July 22, 1925.

Hamilton County, July 23, 1925.

Mahoning County, July 25, 1925, Pomona Grangers;
August 13, 1925, Horticultural Meeting.

Washington County, August 6, 1925, Field Day;
September 29, 1925, Smith-Hughes Day.

Southeastern Test Farm, August 7, 1925, Horticultural Meeting;
August 20, 1925, Field Day;
September 30, 1925, Smith-Hughes Day;
June 18, 1926, Boys' and Girls' Clubs.

Madison County, August 21, 1925.

Northeastern Test Farm, September 8, 1925.

Miami County, September 10, 1925.

Trumbull County, September 11, 1925.

Corn Borer Meeting at the Field Experiments and Laboratory at Bono, September 29, 1925.

Forestry Field Meeting at Shawnee State Forest, September 23, 1925.

CHANGES IN STATION STAFF

RESIGNATIONS

C. W. Montgomery, in charge of District and County Farms; A. E. Miller, assistant in Entomology; W. F. Rofkar, assistant in Horticulture; and Margaret Williams, Librarian.

BY DEATH

W. J. Green, consulting Horticulturist; and H. A. Gossard, chief in Entomology.

APPOINTMENTS

H. W. Bachelor, assistant in Agronomy; J. S. Cutler, assistant in Agronomy; J. T. McClure, assistant in Agronomy; F. R. Dreibelbis, assistant in Agronomy; A. H. Paschall, assistant in Agronomy; M. T. Myers, assistant in Agronomy; J. I. Falconer, chief in Rural Economics; E. C. Newcomer, assistant in Rural Economics; G. F. Henning, assistant in Rural Economics; E. A. Silver, assistant in Agricultural Engineering; J. S. Shoemaker, assistant in Horticulture; Donald Comin, assistant in Horticulture; Curtis May, assistant in Botany; J. D. Sayre, assistant in Botany; J. S. Houser, chief in Entomology; H. L. Gui, assistant in Entomology; E. G. Kelsheimer, assistant in Entomology; J. B. Polivka, assistant in Entomology; M. A. Bachtell, in charge of District and County Farms; L. J. Leffelman, assistant in Forestry; Sarah Painter, Librarian; Elsie Steiger, assistant in Home Economics; and Mary A. Brown, assistant in Home Economics.

PUBLICATIONS

BIMONTHLY BULLETINS

Subjects treated	Year ending June 30, 1926		
	Number pages	Edition printed	Total no. of pages
July-August, 1925			
New Department of Rural Economics			
Recent hog prices			
Shortage of work horses probable			
Index numbers of production			
Alfalfa and clover hay for dairy heifers			
Clover mites and chiggers			
Reel mash feeder			
Poultry investigations	32	75,750	2,424,000
September-October			
Forest protection in Ohio			
Rome Beauty apple as an annual cropper			
Comparison of minerals for swine			
Feeding immature corn			
Fertilizing cereal crops			
Manure supplies crop need for potassium			
Prices of Ohio farm products			
Index numbers			
Sources of income			
The hog situation	32	75,425	2,413,600

Subjects treated	Year ending June 30, 1926 Number pages	Edition printed	Total no. of pages
November-December			
W. J. Green			
Classification of Ohio soils			
Sterilizing soil controls disease			
Fattening heifer calves			
A complete ration essential for winter eggs			
Sunlight and green clover prevent leg weakness of chicks			
Brown patch of lawns and golf greens			
Index numbers of farm taxes, production, etc.	32	76,000	2,432,000
January-February, 1926			
A dairy cow and her progeny			
All-mash method of feeding chicks			
Grain allowance for pregnant and nursing ewes			
Dust treatments for control of oat smut			
Glacial limestone soils of Ohio			
Certified clover seed			
Propagation of grape vines			
Potato situation			
Index numbers of wages, prices, etc.	40	76,470	3,058,800
March-April			
H. A. Gossard			
Alsike clover			
Spring wheat in Ohio			
Emmer not adapted to Ohio			
Intestinal worms in chicks			
Bacillary white diarrhea of chicks			
Potato leafroll			
Seed potatoes for northern Ohio			
The sweet pea			
Old glacial limestone soils			
Sheep and wool production in southern Ohio			
Farm census for Ohio			
Income taxes and index numbers			
State Forests enlarging	48	75,800	3,638,400
May-June			
Fertilizers for corn			
Alfalfa and soybean hay for growing heifers			
Frost injury to the apple			
Peach disease conditions in Ohio			
Poultry houses for pullets			
Farm products consumed on the farm			
Index numbers of crop production			
Cost of living in farm homes of Delaware County, Ohio			
Index numbers of wages, prices, etc.	40	76,500	3,060,000

MONOGRAPH BULLETINS

No.	Title	Number pages	Edition printed	Total no. of pages
385	Blooming period and yield of apples	16	6,000	96,000
386	A study of the mites of Ohio	92	3,800	349,600
387	Subterranean aphids of Ohio	64	3,675	235,200
388	The striped cucumber beetle	128	4,750	608,000
389	Protein requirement of dairy cows	40	3,500	140,000
390	Control of smuts of wheat and oats	24	3,500	84,000
391	Fruit varieties in Ohio	16	8,000	128,000
392	Annual report	100	76,000	7,600,000
393	Spray program	26	6,000	156,000
394	Dependable fruits	36	6,000	216,000

REPRINTS

7	Monograph bulletins	864,000
12	Bimonthly bulletins	628,000

PRESS BULLETINS

52	Press bulletins	104,000
	Total bulletin pages printed during the year	28,235,600

JOURNAL ARTICLES

Bell, D. S., Methods of Management and Medicinal Treatments for the Control of Gastro-Intestinal Parasites of Sheep. Proc. Am. Soc. Animal Production, 1925.

Bethke, R. M. and D. C. Kennard, Does the Growing Chick Require Grit? Poultry Science, Vol. 5, No. 6, Aug.-Sept., 1926.

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Huber, L. L., A Taxonomic and Ecological Study of the Genus Callimome (Chalcidoidea). Smithsonian Institution, U. S. Natl. Museum.

Huber, L. L., S. C. Chandler, and W. P. Flint, Recent Insecticide Experiments in Illinois With Lubricating Oil Emulsions. Natural History Survey, Vol. XVI, Article II.

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Monroe, C. F., and A. E. Perkins, The Mineral Metabolism of Dairy Cows as Affected by Distilled Water and Previous Feeding. Jour. Dairy Science, Vol. VIII, No. 4, July, 1925.

Morris, V. H., and F. A. Welton, The Importance of Clearing the Hydrolyzed Solution in the Determination of Acid-Hydrolyzable Carbohydrate in Green Plant Tissue. Jour. Agr. Res. 33:195-199, 1926.

Newhall, A. G., The Importance of Controlling Celery Blight in the Seed Bed. Phytopath. 16: No. 7, July, p. 467, 1926.

Perkins, A. E. and C. F. Monroe, The Apparent Digestibility of Low Protein Rations by Dairy Cows. Jour. Dairy Science, Vol. VIII, No. 5, Sept., 1925.

Shoemaker, J. S., Pollen Development in the Apple, With Special Reference to Chromosome Behavior. Botanical Gazette 81:148-172, 1926. The Significance of Chromosome Studies in Fruit Breeding. Scientific Agriculture 6:47-49, 1926. Use of Leaf Characters in Identification of Plum Varieties. Proc. Amer. Soc. Hort. Sci., 246-269, 1926.

Simon, R. H., and C. J. Schollenberger, The Acetone Method of Extracting Sulfur from Soil. Soil Sci. XX, No. 5, Nov., 1925. The Rate of Oxidation of Different Forms of Elemental Sulfur. Soil Sci. XX, No. 6, Dec., 1925.

Thatcher, L. E., The Influence of Certain Soil Amendments Upon the Quality of Soft and Winter Wheat in Ohio. Jour. Am. Soc. Agron. 18 (8):629-648, 1926.

Welton, F. A., and V. H. Morris, Climate and the Clover Crop. Jour. Am. Soc. Agron. 17:790-800, 1925. Composition of Grass from Woodland and From Open Pasture. Jour. Am. Soc. Agron. 18:226-238, 1926.

Willard, C. J., Do Legume Leaves Hasten the Curing Process by Pumping Moisture From the Stems? Jour. Am. Soc. Agron. 18:369-375, May, 1926.

Williams, C. G., The Testimony of the Field Experiments of the Country to Soil Deterioration. Jour. Am. Soc. Agron. 18:106-114, Feb., 1926.

Young, H. C., Orchard Pests and Their Control. Proc. 21st An. Conv. Tenn. State Hort. Soc., p. 36, 1926. Comparative Value of Spray Materials. Proc. 21st An. Conv. Tenn. State Hort. Soc., p. 81, 1926.

AGRONOMY

LIVESTOCK VS. GRAIN FARMING

A test of livestock vs. grain-farming systems has been underway for 16 years. A rotation of corn, soybeans for seed, wheat, and clover has been grown. The crops, excepting wheat grain, produced on the half of the land devoted to livestock farming, are fed to cattle running loose in a covered shed and the straw is used for bedding. As soon as the crops grown on the livestock land are fed the manure produced is spread on the sod to be plowed under for corn. In the grain system the corn, soybeans, and wheat are sold and all roughage, including the clover crop, is plowed down for soil improvement. The fertility treatment given in both systems has been 2 tons of ground limestone and 400 pounds of 16 percent acid phosphate per acre on corn and 300 pounds of acid phosphate on wheat. In the livestock system the manure application has been 15.5 tons as a 13-year average.

TABLE 1.—Crop Yields and Manure Production

	1st rotation	2d rotation	3d rotation	4th rotation	16-year average
Corn (bu.)					
Livestock	61.8	67.3	78.6	86.6	73.5
Grain	52.8	64.4	69.6	80.2	66.7
Difference	9.0	2.9	9.0	6.4	6.8
Soybeans (bu.)					
Livestock	25.2	19.4	20.4	26.1	22.6
Grain	21.1	17.4	18.0	22.4	19.6
Difference	4.1	2.0	2.4	3.7	3.0
Wheat (bu.)					
Livestock	33.4	35.6	34.5	31.9	33.9
Grain	27.5	32.0	31.2	29.5	30.2
Difference	5.9	3.6	3.3	2.4	3.7
Clover (tons)					
Livestock	2.43	2.06	2.22	2.29	2.24
Manure produced in livestock system (tons)	*	13.4	15.6	17.8	15.5†

*Weights of manure not determined.
†13-year average.

In Table 1 are shown the crop yields for each system for each rotation of 4 years and the averages for the 16-year period. The average amounts of manure produced in the livestock system are shown for the last 3 rotations. Higher yields of all crops have been produced in the livestock system, the 16-year average differences being 6.8 bushels of corn, 3.0 bushels of soybeans, and 3.7 bushels of wheat. In addition the entire yield of 2.24 tons of clover hay must

be credited to the livestock system. On the other hand, the yields produced in the grain system have been excellent. There is no evidence of any progressive decrease in fertility.

In 12 of the 16 years the manure returned in the livestock system was analyzed for dry matter, nitrogen, phosphoric acid, and potash. As an average for these years the dry matter in the manure was equal to 45 percent of that in the crops fed or used as bedding, assuming the latter to average 80 percent dry matter as harvested. The high fertilizing value of the manure produced from feeding crops of a rotation including two legumes in four years under ideal conditions for preventing losses due to heating, leaching, or seepage is shown by the average analyses. As a 12-year average, each ton of manure applied carried 15.2 pounds of nitrogen, 3.9 pounds of phosphoric acid, and 11.6 pounds of potash. These are fully 60 percent more nitrogen and 40 percent more potash than are contained in the mixed open yard manure produced on the average Ohio farm.

LIME NEEDS OF SWEET CLOVER

That sweet clover is more exacting in its lime needs than red clover is shown by results secured in the Lime and Floats Test begun in 1905. Increasing amounts of quicklime from nothing to 2000 pounds, per acre have been applied to corn in a 3-year rotation of corn, oats, and hay. In 13 years the hay crop was red clover.

TABLE 2.—Relative Response of Red Clover and Sweet Clover to Increasing Amounts of Lime

LIME AND FLOATS TEST

Plot	Treatment	Reaction	Yield	
			Red clover 13-year average	Sweet clover 5-year average
		pH	*Lb.*	*Lb.*
1, 4 Av.	Checks	5.7	3,299	1,399
26	Manure, 8 tons	5.1	3,557	1,215
2	Manure, 8 tons quicklime, 500 lb	6.6	4,611	4,210
3	Manure, 8 tons quicklime, 1000 lb	7.3	4,660	4,849
5	Manure, 8 tons quicklime, 2000 lb	8.2	4,979	6,055

The last 5 hay crops harvested were white sweet clover. Table 2 shows a comparison of the average yields of red clover and sweet clover and the present reaction of the plot soils on the pH scale. It will be noted that with 8 tons of manure but no lime, red clover yielded 3557 pounds. The application of 500 pounds of quicklime

increased the yield to 4611 pounds and brought the soil reaction to pH 6.6, which is slightly on the acid side of the neutral point of pH 7.0. The corresponding yields for sweet clover were 1215 pounds and 4210 pounds. Where the applications of quicklime were 2000, bringing the soil to a decidedly alkaline reaction of pH 8.2, the yield of red clover was increased to only 4977 pounds; whereas the yield of sweet clover was raised to 6055 pounds. Farmers who are supplying barely enough lime to the soil for red clover will do well not to try sweet clover unless additional supplies of lime are provided.

SWEET CLOVER AS A GREEN MANURE CROP

Sweet clover is rapidly gaining in popularity as a plow-down crop, especially on the limestone soils of western Ohio. Such rotations as corn followed by oats or wheat seeded to sweet clover to be plowed down the year following, or corn, oats, red clover, and wheat followed by sweet clover as a plow-down crop are being increasingly used.

Some results have been secured in a 2-year rotation of corn and oats at the Paulding County experiment farm showing the value of sweet clover when used in this way. The test has extended over four years, or two rotations. It includes a comparison of red clover, mammoth clover, and sweet clover, each seeded with the oats and plowed down for corn the following spring. In this work no manure or fertilizer has been used and it has not been necessary to lime for the successful growth of sweet clover. The soil is a heavy phase of the Brookston clay derived from limestone. Altho well tiled, the soil is so impervious that drainage is probably still an important limiting factor.

Eight tons of untreated manure gave increases of 13.5 bushels of corn and 8.3 bushels of oats. In the other test a sweet clover green manure crop increased the yield of corn 18.1 bushels and the yield of oats 9.0 bushels. Altho the comparison is not exact, since the manure was used in addition to a plow-down crop of red clover, it is perhaps not unreasonable to assume that the sweet clover plow-down crop was fully as effective as the application of 8 tons of manure on this soil.

The average yields of corn and oats and the increases due to plowing under the legume crops are shown in Table 3. The corn yield was increased 18.1 bushels and the oats 9.0 bushels by the sweet clover green manure. Figuring corn at 70 cents per bushel and oats at 40 cents, the sweet clover crop made a difference of $16.27 in the value of the crops grown. This is more than double the value of the increase from either the red or mammoth clover.

TABLE 3.—Effect of Plowing Under Legumes in 2-yr. Rotation of Corn, Oats, Legume Plow-down Crop

AVERAGE OF FOUR CROPS, 1922-1925

Plow-down crop	Corn		Oats	
	Yield	Increase	Yield	Increase
	Bu.	*Bu.*	*Bu.*	*Bu.*
None	31.3	.....	40.9	.....
Red clover	39.1	7.8	42.7	1.6
Mammoth clover	38.8	7.5	44.8	3.9
Sweet clover	49.4	18.1	49.9	9.0

On similar soil on the same farm, a 2-year rotation of corn, oats seeded to red clover for a plow-down crop in a fertility experiment involving applications of manure has been in progress 11 years. Table 4 shows the average yields and increases from manure for the period 1922-1925, the same four years for which yields are reported in the preceding test.

TABLE 4.—Effects of Manure in 2-yr. Rotation of Corn, Oats, Red Clover Plow-down Crop

AVERAGE OF FOUR CROPS, 1922-1925

Plot	Treatment	Corn		Oats	
		Yield	Increase	Yield	Increase
		Bu.	*Bu.*	*Bu.*	*Bu.*
7	Check	42.3	.....	38.7	.....
8	Manure, 8 tons	56.2	13.5	47.0	8.3
9	Phosphated manure, 8 tons	57.3	14.1	48.7	10.0
10	Check	43.6	.....	38.7	.....

ACTION OF GRANULATED SLAG ON ACID SOILS

Much uncertainty exists as to the comparative value of granulated slag and other forms of lime for use on acid soils. Due to the recent appearance of slag on the market for agricultural use, sufficient opportunity has not been given for establishing its value thru crop yields secured in field experiments. Some data have been secured at the Ohio Station upon the comparative rates at which the acidity of small field plot and cylinder soils has been corrected by slag and ground limestone over a 29-month period. The relative value of slag indicated by these results may need to be changed in case further work shows that slag possesses any secondary property that increases crop yields aside from its power to correct soil acidity.

The neutralizing power and fineness of the materials used are shown in Table 5. Table 6 shows the soil reaction at 9 weeks and 29 months after treatment and the decrease in lime requirement during 29 months for the small field plots and cylinders, respectively. The granulated slag used was the water-cooled slag now being sold in the State. The ground slag was prepared by grinding the granulated slag to the approximate fineness of the limestone used. Up to the present time no ground slag has been offered for sale in Ohio.

TABLE 5.—Neutralizing Power and Fineness of Slag and Limestone

	Neutralizing power (as percent $CaCO_3$)	Percent passing sieves of			
		4-mesh	10-mesh	50-mesh	100-mesh
Ground limestone.....	88.8	100	94	43	34
Ground slag.	84.0	100	99	71	30
Granulated slag.	84.0	98	85	6	4

TABLE 6.—Comparative Effect of Limestone and Slag on Acidity of Soils

Treatment	Reaction after*		Reduction in lime requirement† during 29 months $CaCO_3$ per acre	
	9 weeks pH	29 months pH	Total Lb.	Per ton applied Lb.
Plot soils				
Ground limestone, 2 tons.....	4.9	5.4	2,665	1,333
Ground slag, 2 tons.....	4.7	5.0	1,625	813
Granulated slag, 2 tons.....	4.5	4.9	715	358
Granulated slag, 4 tons.....	4.5	5.0	1,095	274
Granulated slag, 6 tons.....	4.7	5.1	1,945	324
Cylinder soils				
Ground limestone, 4 tons.....	6.3	7.2	2,350	588
Ground slag, 2 tons.....	6.0	6.6	1,010	253
Granulated slag, 4 tons.....	5.6	6.2	500	125

*Untreated plot soil had a reaction of pH 4.5 after 9 weeks and pH 4.8 after 29 months. Untreated cylinder soil had a reaction of pH 5.6 after 9 weeks and pH 6.1 after 29 months.

†Determined by modified Jones method. Untreated plot soil showed a lime requirement of 7125 pounds after 29 months. Untreated cylinder soil showed a lime requirement of 4010 pounds after 29 months.

‡Each figure represents the average for 5 cylinders.

Granulated slag was slower in its action than ground limestone. As an average for the three plats receiving this material, 1 ton of slag reduced the lime requirement 319 pounds compared to a reduction of 1333 pounds for 1 ton of ground limestone. In other words it required 4.2 tons of slag to effect the same correction of soil acidity as 1 ton of limestone. Figured in the same way from the

cylinder experiment, it required 4.7 tons of slag to do the work of 1 ton of limestone. Grinding more than doubled the effectiveness of the slag, but its value was still only 61 percent as great as ground limestone in the plot experiment and 43 percent as great in the cylinder experiment. It would appear that slag must be applied in liberal quantities if results equal to those from limestone are to be expected.

CHANGES IN SOIL ORGANIC MATTER AND NITROGEN UNDER LONG CONTINUED CROPPING

A number of fertility plot experiments have been underway at Wooster for a long period of years, several having been begun in 1894. These have involved various crop rotations and the use of a great variety of manure, lime, and fertilizer applications. An extensive study of the chemical, physical, and biological properties of these old plot soils was recently undertaken. Fortunately, there are still available samples of soil taken at the beginning or in the early years of these experiments. From analyses of these samples it is possible to determine the approximate composition of the soil at the time the work was started. Large changes have taken place in the composition of the soils of many of these plots, depending upon the cropping and fertility systems practiced. The changes in the contents of organic matter and nitrogen are especially significant. In Table 7 are shown the amounts of organic matter and nitrogen now present in limed but otherwise untreated plots that have been under different cropping systems.

TABLE 7.—Effect of Cropping System Upon Soil Organic Matter and Nitrogen. Land Limed and Drained, But Otherwise Untreated

Cropping system	Years	Pounds per acre in suface soil	
		Organic matter*	Nitrogen
Corn, continuous	32	12,516	820
Oats, continuous	32	21,722	1,300
Wheat, continuous	32	21,826	1,320
Corn, oats, wheat, clover, timothy, rotation	32	26,515	1,540
Corn, wheat, clover, rotation	29	29,549	1,760
Original soil (approximate)		36,825	2,240

*Organic carbon × 1.724.

Continuous cropping to corn has been destructive of organic matter and nitrogen, probably because of the stimulating effect of the cultivation upon the decomposition processes in the soil and because of the relatively small root and stubble residues left by the

corn crop. Continuous cropping to oats or wheat has resulted in less loss of these constituents, but the supply is now much lower than where a rotation including sod crops has been grown. The 5-year rotation with the land in hay two-fifths of the time has resulted in larger losses of both organic matter and nitrogen than the 3-year rotation with the land only one-third of the time in hay, but this a clover crop. The bigger residues left by the larger crops grown in this rotation and the higher nitrogen content of these residues probably account for this difference. Even where a clover sod has been plowed down every third year there has been an apparent loss of about one-fifth of the original organic matter and nitrogen in the 29 years during which nothing has been returned to the land but the roots and stubble of the crops harvested.

TABLE 8.—Effect of Manure, Fertilizers, and Lime on Soil Organic Matter and Nitrogen

Rotation: Corn, Oats, Wheat, Clover, Timothy (Section D)

Plot	Treatment per rotation	Years	Pounds per acre in surface soil, 1925			
			Organic matter*		Nitrogen	
			Limed	Unlimed	Limed	Unlimed
Av.	Checks—none	32	26,520	26,550	1,540	1,540
14	Nitrate of soda, 320 lb. / Acid phosphate, 240 lb. / Muriate of potash, 180 lb.	32	27,620	32,410	1,620	1,780
20	Manure, 8 tons	32	32,340	32,790	1,900	1,900
18	Manure, 16 tons	32	36,510	35,650	2,000	2,000
	Original soil (average 22 plots)		36,825		2,240	

*Organic carbon × 1.724.

In Table 8 are shown the contents of organic matter and nitrogen for some of the differently treated plots in the 5-year rotation experiment. The liberal application of stable manure 116 tons per acre, applied to Plot 18 has maintained the organic matter of the soil approximately at its original level, altho there has been some loss of nitrogen. Excellent yields of all crops have been maintained upon the limed end of this plot and there has been no significant change in the level of yields since liming was begun in 1903. The yields on the unlimed end have been lower but the level of yields during the last 10 years was higher than for the first 10 years of the test. The organic matter and nitrogen in this soil at the beginning of the experiment were both low, each about two-thirds the content of the average soil of Ohio. It would appear that, on soil of this type (Wooster silt loam), it is not necessary to increase the

soil's organic matter and nitrogen content to maintain excellent yields. Further, it would appear almost impossible to do so without the return of more manure and crop residues than can be supplied in practice.

Plot 20, 8 tons of manure, and Plot 14 a complete fertilizer, receive approximately the same amounts of the fertilizing elements, nitrogen, phosphoric acid, and potash. The present level of crop yields on these two plots is almost identical as are also the average yields since the beginning of the experiment. This is true in spite of the larger losses of organic matter and nitrogen that have taken place on the chemically fertilized plot. Here again it appears that the supplying of the necessary fertilizing constituents is more important for maintaining crop yields than is the maintenance of the supply of organic matter and nitrogen in the soil. The Wooster silt loam is a soil of almost ideal physical structure. It is possible that different results would be secured on soils of heavier or lighter texture where the physical effect of soil organic matter is of greater importance.

EXCHANGE BASES IN FERTILITY PLOT SOILS

Recent investigations have established the great importance of that part of the soil's supply of basic elements which is removed when leached with salt solutions. With those elements used by plants, the amount present in form to be thus displaced is probably the best measure of the amount available to plants. Further, the physical properties of the soil colloids, with which these bases are almost entirely associated, may be greatly affected by the amount and nature of the exchange bases. Such variations are reflected in the physical properties of the soil. For example, where exchange calcium predominates the soil is apt to be well granulated and easily permeable to air and water. Where exchange sodium predominates, the soil is apt to be compact and impermeable.

A study is being made of the effect of long continued fertilizer, manure, and lime treatments upon the amount and character of the exchange bases in some of the fertility plot soils of the Ohio Station. The results throw much light upon the fate of the various basic elements applied and indicate the extent to which the physical properties of the soil may be affected by long continued use of such fertilizers as nitrate of soda and acid phosphate. The process of analysis consists in leaching the dried soil samples with a neutral solution of ammonium acetate and determining the exchange bases in the extract.

The soils of Section D of the 5-year rotation experiment, now in its 33d year, have been studied most. The results may be summarized as follows:

The surface soils of one acre have an absorptive capacity that for saturation requires bases equivalent to the lime contained in 4 tons of limestone. In the unlimed soils this absorptive capacity is about 25 percent saturated with basic elements such as calcium, magnesium, potassium, sodium, etc. and about 75 percent saturated with acid hydrogen. On the limed soil the corresponding figures are 96 percent and 4 percent, respectively.

Of the total calcium and magnesium applied in the form of 16 tons of limestone, the equivalent of 1.3 tons now remains in the form of undecomposed carbonates. Three tons of the original limestone is represented by increases in exchange calcium and magnesium while nearly 12 tons has been lost in crops and drainage. Liming has materially reduced the amount of exchange sodium and potassium, probably as a result of increased removal in the larger crops grown. The amounts of exchange aluminum and manganese have been largely decreased by liming.

For twelve plots that have each received 260 pounds of muriate of potash per rotation there are present, as an average, 116 pounds of exchange potassium per acre on the limed ends and 194 pounds on the unlimed ends. The average amount of exchange potassium in the soils of the check plots is 72 pounds per acre for the limed ends and 76 pounds for the unlimed ends. Of the total potassium applied on the twelve fertilized plots, 5 percent now remains in exchange form in the limed soil and 14 percent in the unlimed soil. The remainder presumably has been used by crops or lost in the drainage.

The use of nitrate of soda has not in any case resulted in the retention of any considerable amount of active sodium by the surface soil. The unlimed end of Plot 12, receiving 680 pounds of nitrate of soda per rotation, contains 94 pounds of exchange sodium per acre, the limed end 70 pounds. These compare with an average of 11 pounds for all checks. The retention is insignificant in comparison with the amount the soil has received, and sodium now comprises only about 2.5 percent of the total exchangeable bases even in case of the higher figure. It may be concluded that injury from the free use of nitrate of soda upon soils of this type under Ohio conditions is not to be expected.

MANURE FROM STRAW AND CORN STALKS

Market gardeners have long followed the practice of composting straw, leaves, and other crop residues in order to reduce such materials to a form best suited for use on the land. Various materials including lime, ashes, and fertilizers have been incorporated to hasten decomposition or strengthen the resulting product. As the result of extensive study of the effects of adding various substances to composts at the Rothamsted Station in England a patented chemical known as "Adco" has recently been placed on the market both in England and America. The use of 150 pounds of this material for each ton of dry straw or other residues in a compost is supposed to greatly facilitate the process of decomposition and give a product quite similar in composition and fertilizing value to stable manure.

Such "artificial manure" may prove to be a satisfactory substitute for stable manure in greenhouse culture or vegetable gardening. It is also possible that the process may find limited use as a means of disposing of corn stover not otherwise usable for feed or bedding under corn borer conditions. Studies were begun at the Ohio Station aiming to determine (1) the comparative efficiency of "Adco" and a combination of sulfate of ammonia and ground limestone for the process, (2) the field value of artificial manure from straw and stover, (3) the minimum amount of water required.

The only results yet ready to report relate to the chemical composition of the artificial manure produced from corn stover when composted with "Adco" as compared to sulfate of ammonia carrying an equal amount of soluble nitrogen and supplemented with ground limestone. Two compost piles were built, using 1 ton of shredded corn stover in each. In one pile 150 pounds of Adco was incorporated; in the other 65 pounds of sulfate of ammonia and 150 pounds of ground limestone. In making the piles an 8-inch layer of shredded stover compacted by tramping, and about 10 feet square, was placed on level ground in the open. A part of the chemicals was scattered over this and the stover then saturated with water. Successive layers of compacted stover and chemicals, thoroly moistened, were placed on top of this until the entire ton of stover and the full amount of chemicals were used. Rapid decomposition began at once and within 48 hours both piles attained a temperature of about 140° Fahrenheit. More water was added at this time and again at intervals of 2 or 3 days, whenever the temperature was thought to be too high. After 2 weeks the piles were forked

over and more water added. They were then allowed to remain undisturbed for about 3 months when they were torn down and samples taken for analysis. A total of around 600 gallons of water was added to each pile.

Table 9 shows the fertilizing constituents contained in the stover and chemicals and in the resulting manure. The losses incident to the process are also given. For comparison the losses in burning 1 ton of stover are shown.

TABLE 9.—Fertility Constituents Lost in Artificial Manure Process and in Burning

	Total	Nitrogen	Phosphorus	Potassium
	Lb.	*Lb.*	*Lb.*	*Lb.*
Fresh stover	2,000	18.0	2.55	16.2
Adco	150	13.7	5.10	0.9
Total	.....	31.7	7.65	17.1
Artificial manure	4,200	17.8	7.90	6.9
Loss	.....	13.9	—.25	10.2
Fresh stover	2,000	18.0	2.55	16.2
Sulfate of ammonia	65	13.2	.....	.....
Total	.....	31.2	2.55	16.2
Artificial manure	4,070	13.8	2.87	6.5
Loss	.....	17.4	—.32	9.7
Fresh stover	2,000	18.0	2.55	16.2
Ashes	242	.4	2.49	13.5
Loss	.....	17.6	.06	2.7

The products from the two piles were quite similar in appearance and not far different in composition. The "Adco" manure contained more phosphoric acid—due to its addition in the chemical used—and also a little more nitrogen. The losses of both nitrogen and potash were so high from each pile as to render either method of doubtful economy. Since it is probable that leaching was responsible for most of this loss, later experiments are being conducted using concrete floors which permit the recovery of the leachings and their return to the pile.

One ton of the "Adco" manure contained 8.5 pounds of nitrogen, 3.8 pounds of phosphorus, and 3.3 pounds of potassium. C. E. Thorne estimates that 1 ton of mixed open yard manure from horses and cows will carry about 9.0 pounds of nitrogen, 2.2 pounds of phosphorus, and 6. 7 pounds of potassium. Hence, on the basis of chemical composition, a ton of the artificial manure is but slightly inferior to a ton of average yard manure.

EFFECT OF FERTILIZERS ON GERMINATION AND NODULE FORMATION OF SOYBEANS, PRELIMINARY REPORT

A study of fertilizer additions as a possible factor contributing to poor growth and inoculation of soybeans has been undertaken.

The fertilizers used in the first year's investigations, 16-per-cent acid phosphate, 0-10-10, and 0-14-4, were applied at rates of 100, 200, 300, and 400 pounds per acre. Each fertilizer was placed in four different positions with respect to the seed: with the seed, four inches at the side of the seed, one inch below the seed, and on the surface of the soil. The fertilizers covered an area in the soil equivalent to that obtained by a fertilizer attachment on a disc drill. Manchu seed was inoculated with a virulent strain of soybean bacteria and planted one inch below the surface of the soil, Volusia silt loam.

One hundred pounds of fertilizer placed with the seed had no appreciable effect on germination. Two hundred pound additions of acid phosphate was similarly without effect, altho an equal amount of either 0-14-4 or 0-10-10 reduced the germination to around 25 percent. The 300 and 400 pound applications of any analyses were decidedly harmful when placed with the seed. Of the plants that grew 70 percent for application of acid phosphate and 15 percent for applications of 0-10-10 were inoculated with 3 to 5 nodules per plant. The 0-14-4 occupied an intermediate position with regard to toxicity.

The same fertilizers in amounts up to 400 pounds per acre when placed below, above, or at the side of the seed gave no reduction in germination and resulted in the inoculation of 80 to 100 percent of the plants with 15 to 20 large nodules per plant. The larger additions gave more nodules per plant and a greater number of inoculated plants.

PROGRESS OF THE OHIO SOIL SURVEY

In 1912 a general or reconnaissance soil survey of Ohio was completed and the report published. Since that date work has been in progress on a detailed soil survey by counties. At the end of the field season of 1926, nineteen counties had been surveyed. Of this number the maps and reports have been published for ten counties. The accompanying map shows the location of the counties for which the reports are available. During 1926 field work was completed in Scioto and Washington Counties, and soil survey work was started in Butler, Belmont, Licking, and Putnam Counties. It is planned to complete these areas in 1927.

The soil survey of the State is being carried on in cooperation with the Bureau of Soils, U. S. Department of Agriculture. The maps and reports are being published by the Bureau of Soils and are available for free distribution thru either the Bureau of Soils, Washington, D. C., or the Experiment Station, Wooster, Ohio. The supply for free distribution of the Reconnaissance or General Soil Survey of Ohio is practically exhausted. It can be secured for 25 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Beginning in 1925 the Experiment Station started the publication of a series of State Soil Survey Reports in which it is proposed to stress the results of field, greenhouse, and laboratory studies by the Experiment Station on various soil types. The first number of this series, Soil Survey of Miami County, Ohio, is now available for distribution.

The soil survey of Ohio is being made for the purpose of classifying and mapping all the soils of the State, so that the Experiment Station may give specific information, thru soil reports

and by correspondence, on the location of different types of soils, and on their fertilization and management. Altho detailed soil surveys have not as yet been made of all of the counties, considerable information is available concerning the soils of all parts of the State.

THE RELATION OF CROP ROTATION TO YIELD OF WHEAT

Twelve years ago this Station started forty different rotations ranging in duration from two to five years with eleven standard Ohio crops. Each crop in each rotation has been grown every year, thus reducing the effect of seasonal variation upon the result to the minimum. The soil treatment has been the same regardless of the rotation. This treatment consists of an application of two tons of ground limestone per acre every four years; an average of two tons of stable manure per acre per year; and an average application of 200 pounds of 16 percent acid phosphate per acre per year.

Winter wheat is grown in thirty of these rotations. In twelve rotations wheat follows corn; in six, soybeans; in six, potatoes; in three, oats; and in three, clover.

The ground is plowed for wheat following oats and clover, but disked only following corn, soybeans, and potatoes.

Progress reports of this work have been made from time to time. In the present report the yield of wheat following different crops is considered, both with respect to the crop immediately preceding and also the second crop preceding wheat.

TABLE 10.—Wheat Following Different Crops, 11-year Average Yield per Acre

	Bushels
Wheat following soybeans.....(66 crops)..	33.33
Wheat following corn.....(124 crops)..	34.31
Wheat following oats.....(33 crops) .	37.34
Wheat following clover.....(33 crops)..	39.11
Wheat following potatoes.....(62 crops)..	39.65

As indicated by the above table, the yield of wheat has averaged highest following potatoes, with clover a close second, oats third, corn fourth, and soybeans fifth.

The yield of wheat following these five crops has varied quite a little in the different rotations, as will be noted in Table 11, which gives the second crop preceding wheat.

The corn rotations.—Where a legume precedes corn in the 3-year rotations the yield of wheat averaged quite a little higher than where timothy precedes corn, with alfalfa leading the clover

TABLE 11.—Wheat Yields Immediately Following Corn (A), Soybeans (B), and Potatoes (C) With Crops Preceding the Corn, Soybeans, or Potatoes as Indicated

Rotation No.	Length of rotation, years	Crop preceding corn	Number of crops harvested	Average yield per acre, bushels
		A, Corn		
11	3	Red clover	11	37.25
13	3	Sweet clover	11	36.84
14	3	Alfalfa	11	38.51
15	3	Timothy	11	34.23
23	4	Corn	11	30.84
25	4	Potatoes	11	35.47
29	4	Oats	7	33.04
32	5	Timothy	11	35.07
33	5	Corn	11	29.47
38	5	Corn	11	32.43
39	5	Oats	7	36.20
		B, Soybeans		
19	3	Red clover*	11	38.73
26	4	Potatoes	11	35.53
27	4	Corn	11	32.35
35	5	Corn	11	30.15
36	5	Potatoes†	11	32.81
		C, Potatoes		
17	3	Red clover	11	42.14
20	3	Soybeans	7	37.50
24	4	Corn	11	38.29
34	5	Corn	11	39.58
37	5	Soybeans‡	11	41.55

*This rotation is soybeans, wheat, clover; the soybeans being manured.
†A crop of corn precedes the potatoes.
‡Another crop of potatoes precedes the soybeans, the rotation being potatoes, soybeans, potatoes, wheat clover.

slightly. In the 4-year rotations the wheat yields are in the same order with reference to the second preceding crops as they are with the first. If the yield of wheat in rotation 32 is a little higher than one might expect, it may possibly be accounted for by the rather unusual rotation, namely; corn, wheat, clover, timothy, timothy—only one plowing and one cultivated crop in 5 years.

The soybean rotations.—There is only one exceptionally high yield in these rotations, No. 19, and this is easily accounted for. This rotation is soybeans, wheat, clover; the soybeans getting the manure of the rotation as well as the clover sod. Rotation 36 is doubtless inferior to 26 in wheat yield, because in the former corn precedes potatoes, while in the latter clover precedes potatoes.

The potato rotations.—Rotation 17 is entitled to lead in accord with previous findings, while the other rotations except 37, behave normally. This apparent contradiction may possibly be accounted for in that a crop of potatoes precedes the soybeans, the full rotation being potatoes, soybeans, potatoes, wheat, clover.

The oats and clover rotations are not included in this study of the effect of the second preceding crop because there are only three of each.

Just what bearing the corn borer infestation will have upon Ohio's popular corn, wheat, clover rotation is not yet determined. Certainly corn stubble cannot be plowed for wheat. There is not time to do this, nor would such a loose seedbed be satisfactory. It is possible that the corn-stubble beater will solve the problem.

BARLEY AND SPRING WHEAT COMPARED WITH OATS

The failure to plant the expected acreage of winter wheat in Ohio in the fall of 1926 has created an interest in spring wheat and barley as possible substitutes rather than to use oats, the acreage of which promises to be larger in 1927 than usual. It seems timely, therefore, to call attention to the relative yields and stability of spring wheat, barley, and oats as measured by tests on eleven experiment farms well distributed over the State as shown in Table 12.

TABLE 12.—Barley, Spring Wheat, and Oats

ACTUAL AND RELATIVE YIELDS OF GRAIN ON EXPERIMENT FARMS IN OHIO

Location		No. years tested	Pounds grain per acre			Relative yields Oats=100	
County	Experiment farm		Oderbrucker barley	Spring wheat	Miami oats	Barley	Spring wheat
Miami	County	5	1,260	902	1,757	71.7	51.3
Paulding	County	7	1,219	888	1,575	77 4	56 4
Madison	County	7	1,108	875	1,584	69 9	55.2
Hancock	District	5	1,357	868	1,708	79 5	50.8
Hamilton	County	9	1,270	643	1,414	89 8	45 5
Trumbull	County	8	1,200	831	1,705	70 4	48 7
Mahoning	County	10	1,279	1,007	1,943	65.8	51.8
Belmont	County	8	1,357	819	1,765	76.8	46 4
Cuyahoga	District	8	...	1,212	2,070	...	58 5
Meigs	District	4	1,022	430	1,230	83.1	34 9
Wayne	State	14	1,556	1,073	2,258	68 9	47.5
			Barley	Emmer	Miami oats	Barley	Emmer
Wayne	State	10	1,373	987	2,129	64.5	46 3

*Includes 19 Marquis and 56 Blue Ribbon tests

The yields of grain are given in pounds per acre for direct comparison. The varieties used are high yielding, well adapted sorts.

On the average barley yielded about 75 percent and spring wheat 50 percent as much as oats.

Some few farmers may consider emmer in this connection. A ten-year average test at Wooster shows that emmer is comparable to spring wheat in yield. As a cash crop it is much less desirable than spring wheat or barley.

Spring wheat uncertain.—Spring wheat is less dependable than barley and both are less so than oats or winter wheat, as shown by the yearly variation in yields of these four crops for a 17-year period at Wooster. Spring wheat during this period averaged 16.7 bushels per acre and ranged from a total failure in 1915 to 27.8 bushels in 1923. The 17-year average of all the fluctations in yield from the 16.7 bushels was 7.36 bushels, or 44 percent of the average yield. Barley ranged from 14.2 bushels in 1911 to 59.4 bushels in 1918 and averaged 32.4 bushels for the 17-year period. The average yearly variation was 9.3 bushels, or 29 percent, a much more stable crop than spring wheat.

Oats ranged from 40.5 bushels in 1913 to 94.5 bushels in 1918, and averaged 64.3 bushels for the 17-year period, the average yearly variation being 9.3 bushels, or 15 percent. Winter wheat ranged from 18.1 bushels in 1920 to 55.0 bushels in 1926, and averaged 34.4 bushels for the period, with an average yearly variation of 6.4 bushels, or 19 percent.

Comparison of varieties.—One or more varieties of spring wheat have been grown at Wooster each year since 1908, and four varieties each year of an 8-year period. The 8-year average yields are Groff, 14.7 bu.; Blue Ribbon, 13.7 bu.; Marquis, 10.4 bu.; and Blue Stem, 9.9 bu.

The durum variety, Kubanka, was grown for a different 5-year period in comparison with Groff. On the basis of the yield of Groff in the 8-year period, Kubanka should have averaged for the 8 years 8.6 bushels per acre. The durum or macaroni wheats should be avoided by Ohio farmers because of low yield and also because of the difficulty of disposing of this class of wheat in our terminal markets.

Ohio farmers should have no difficulty in securing seed of Blue Ribbon (generally called Preston in the northwest) and of Marquis. Groff is a local variety grown in Ohio several years ago. There is no visible supply of this variety at the present time. Spring wheat is grown to a limited extent in a few counties in northwestern Ohio with fair success. Yields in other parts of the State are very uncertain.

Early seeding and liberal fertilization important.—The danger of total failure may be minimized to a certain extent by growing the right variety, seeding early, and using liberal amounts of commercial fertilizer. An application of 300 to 400 pounds per acre of a 3-12-4 analysis is suggested for light colored soils and an equal amount of 2-16-2 for dark colored soils.

Barley adapted to northwestern Ohio.—Two-thirds of Ohio's barley crop is grown in northwestern Ohio or two-fifths of the state's area. Some expansion of the acreage in this section of the State may be desirable. Barley requires a soil well supplied with lime and its successful culture on soils not of limestone origin may be limited by this factor.

WOODLAND PASTURE

Foresters discourage the use of woodland as pasturage; for they contend that pasturing results in injury thru defoliation, cropping of bark and stems, uprooting and killing seedlings, exposing the roots of older trees by trampling, and at the same time making difficult the starting of seedlings.

Farmers are not inclined to abandon the use of woodland as pasture for they feel they cannot sacrifice the feed. This feeling is accentuated by the steady decline in the productivity of their permanent pastures. At the same time, however, it is thought by many stockmen that woodland pasture is not eaten with the same relish as pasture grown in the open.

To study the effect of shade on the production and composition of bluegrass two areas, each containing three square rods, were laid off in the spring of 1924; one in a woods, the other in an open pasture field adjoining. The area in the woods was completely carpeted with grass. It was partly shaded all the time but not completely shaded any of the time. The light in the woods, as measured on four different dates by Ridgeway's chemical photometer, ranged from 76 to 90 percent less than that in the open.

The latter part of the season was very dry, so that four clippings only were made during the summer. Altho both areas appeared clean in the spring, many weeds developed during the summer, the quantity being much greater in the woods than in the open. The yield of grass produced in the woods was approximately 85 percent less than that grown in the open. In feeding value, analyses showed that the woodland grass contained 22 percent less total nutrients per pound than grass from the open pasture. The total carbohydrates found in the green material were 38 percent less in the woodland than in the open pasture, much of the difference being due to the presence of a smaller quantity of inverted sugar in the woodland pasture. A difference in these compounds suggests that there probably is a real difference in palatability between woodland and open pasture, the former being relished less than the latter.

PURE-LINE DEVELOPMENT IN CORN

For a number of years there has been much interest, thruout the corn producing sections in what is called the pure-line method of corn breeding. By this method individual plants are inbred by controlled pollination. By continuing this system very uniform strains are obtained after a few years. These strains, however, differ from each other markedly.

Inbreeding brings out the most undesirable characteristics of the corn, and those strains which inherit these unwanted qualities are eliminated. All strains are reduced in vigor, but the vigor may be regained by crossing.

The Station has done three years' work in pure-line corn production. In this time there were produced about two hundred strains which will be used in continuing the work. These strains have largely been selected from many times that number of possible ones, on the basis of some combination of the following points: stiffness of stalk, firmness of root system, apparent freedom from disease, ability to mature sound corn, leaf area, resistance to loss of vigor under inbreeding, and desirable grain and ear type.

Eliminations have been made mainly because of tendency to lodge, either by the roots' giving way or by the stalks' breaking; tendency to rot; extreme reduction in vigor, some are not able to propagate themselves after second or third year; spindly stalks; very starchy grain; chaffy or unsound ears. All of these conditions become exaggerated among the strains under the trying process of pure-line production.

The planting in 1927 will include several groups of strains, the strains of each group having one or more characteristics in common: a "sturdy" group of strains in which the plants are low down with thick stiff stalks; a "stiff" group of strains of plants that stand well, but may be tall or even slender; a third group of strains that have stubbornly retained their vigor under inbreeding; a small "lodger" group with plants that spread themselves on the ground at the first opportunity; and a "high leaf area" group, of interest from a fodder standpoint.

Preliminary crosses for the production of vigorous strains to compete in yield trials with our present commercial sorts will be made in 1927. Definite predictions as to the ultimate results cannot yet be made.

A STUDY IN METHODS OF CEREAL TESTING

The agricultural world is continually interested in comparisons among the many varieties of crop plants. Our ability to select the

best is in no small measure a factor in determining the total crop production. Since the Experiment Station must make hundreds of such comparisons each year, a statistical study on the most advantageous size, shape, and number of replications for cereal test plots has been in progress for three years. Records covering 5 to 15 years work have been used. A measure of plot reliability can be made by the degree of consistency in results obtained.

The following points have been brought out in this study:

Conclusions based on a comparison of single plantings, whether they be plots or fields, have little value.

Comparisons based on only one year of work are liable to be misleading.

The use of checks, that is, systematically distributed plots of uniform seeding and treatment, with which the trial plots are compared, is of significant value in gaining reliability among larger field plots.

The use of checks is of doubtful value in nursery trials.

Intervarietal competition is not a factor of importance disturbing the results of single row nursery tests in small grains where rows are 1 foot apart and adjoining varieties are not markedly contrasted in vigor of growth.

A given area devoted to replicated small plots will yield far more reliable results than single large plots.

Increasing plots in length is relatively more effective in gaining reliability than is increasing them in width.

RESISTANCE TO SMUT AMONG WHEAT VARIETIES

Resistance to covered or stinking smut among varieties and strains of wheat was studied in connection with cereal breeding work in 1925 and 1926. Each sort in the test was grown under inoculation for the disease and its percentage of infection determined. Rather marked differences were noted in varietal resistance to this disease. While certain varieties showed complete resistance none of these are satisfactorily adapted to Ohio conditions. Crosses between some of these varieties and our best yielding strains were made.

A comparatively high degree of resistance is shown by Trumbull and with a little less certainty by Fulhio. An added point in favor of Trumbull is that preliminary inoculation tests, as well as field notes and growers' observations, indicate that it is practically immune to the loose smut. The following varieties were easily smutted: Poole, Fultz, Nigger, Fulcaster, Goens, Mediterranean, Gladden, Portage, Ohio 9920, and Leaps Prolific.

BOTANY AND PLANT PATHOLOGY

APPLE SCAB STUDIES AND SPRAY SERVICE

This work has been in progress three years, and again the life cycle of the scab organism has received the most emphasis. It has been by such studies that a definite spray service procedure has been formulated.

The correct timing of the application of the pre-blossom spray is necessary for control of initial scab infection. If successful in this the grower has little difficulty in controlling subsequent infection. Moreover, if he is successful in this early season work he will be able to save material and labor in later applications and at the same time produce a better grade of fruit. The cutting down of sprays naturally reduces spray injury.

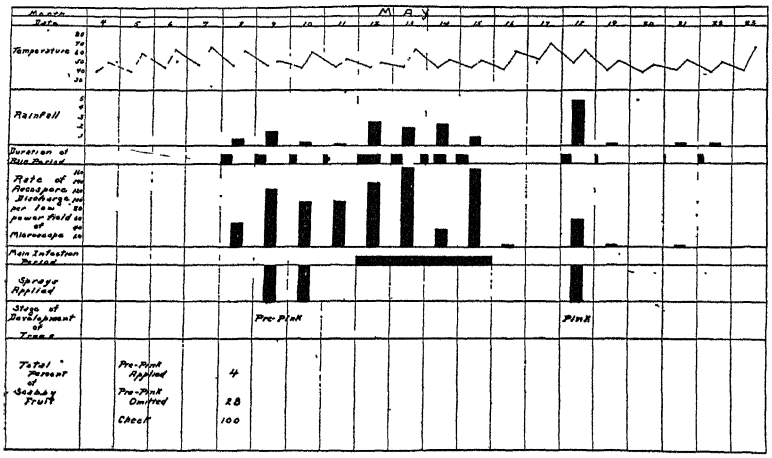


Fig. 2.—Bingham Orchard 1924

Chart showing Temperature, Rainfall, Duration of rain period, Ascospore discharge, Infection period, Development of trees, and Percentage of scabby fruit.

In this work it was found that timeliness in the control of scab can be determined only by a complete knowledge of the fungus causing the disease. In turn, the development and activity of the fungus depend almost entirely upon climatic factors, which exert an influence over a period beginning in the fall even before the old infected leaves drop and extend thru May and June of the following year. A detailed study of this correlation has enabled us to predict in advance the scab-infection periods in the spring. By the use of

a microscope in the orchard and a small laboratory room with a few small glass moist chambers it is possible to follow the development of the fungus and determine in advance, sometimes several days, when and under what conditions it will ripen and discharge its spores. The spores will be discharged and infection will take place only during rain periods. An effective spray service, therefore, is made possible, first by a knowledge of the fungus, and second by a rain period forecast of three days.

The difficult part in conducting such a spray service is due to the variation in the development of the fungus. Scab-spore discharge may vary as much as a week in the same county, consequently a large number of trained observers are necessary for such spray service work.

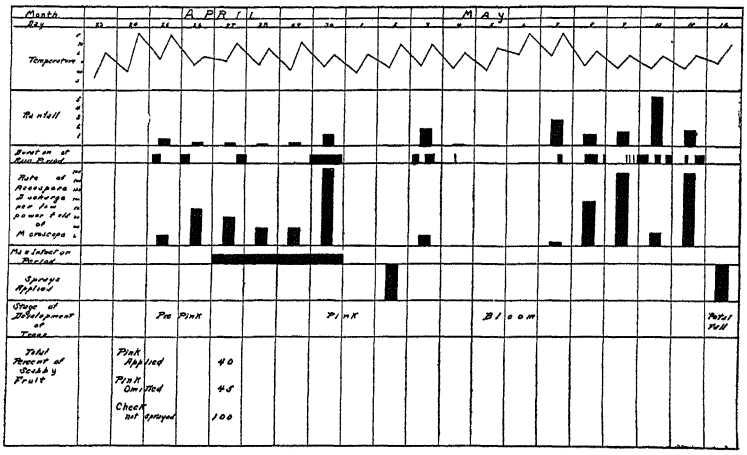


Fig. 3.—Hartman Orchard 1924

Another important item is the forecasting of the weather. During the spring of 1926 we received excellent service and cooperation from the U. S. Weather Bureau. A one-, two-, and three-day forecast was given daily from Washington, Cincinnati, Parkersburg, Columbus, and Cleveland. Tho the largest element of chance is in the weather, yet the predictions in 1926 were perfect for our work. An example of this is shown in Table 13.

Possibly, other years may not be as easily forecast as 1926, but when all factors are considered, there seems little chance for failure to control scab.

Figures 2 and 3 show the time to spray in relation to weather. Note that no consideration is given to the stage of development of the apple tree. Both charts show the necessity of a pre-pink spray.

This spray was applied in one case but not in the other. Similar charts were prepared of each season's results.

In 1926 the spray service proved very profitable to the fruit grower. It enabled him to save labor and large quantities of materials and to grow clean fruit. The weather in most places, as was predicted thruout the period, was unfavorable for scab development.

TABLE 13.—Rain Forecast, April, 1926, Cincinnati District

FORECAST BY W. C. DEVEREAUX

Date	Forecast in advance			Weather	Precipitation	Prediction
	3 days	2 days	1 day			
1	.....	.....	.....	Fair	.....	.....
2	.....	.....	.....	Cloudy	.02	O. K.
3	Fair	Prob. light shower	Light shower	Light shower	T.	O. K.
4	Fair	Fair	Fair	Fair	.....	O. K.
5	Fair	Fair	Fair	Fair	T.	O. K.
6	Rain	Rain	Rain	Rain	.68	O. K.
7	Rain	Rain	Rain	Rain	.34	O. K.
8	Rain	Rain	Rain	Rain	1.54	O. K.
9	Fair	Fair	Fair	Fair	.....	O. K.
10	Fair	Fair	Fair	Light shower	.04	O. K.
11	Light rain	Light rain	Light rain	Light drizzle	.12	O. K.
12	Fair	Fair	Fair	Fair	.....	O. K.
13	Fair	Fair	Fair	Fair	.....	O. K.
14	Fair	Fair	Fair	Fair	.....	O. K.
15	Fair	Fair	Fair	Fair	.....	O. K.
16	Fair	Fair	Fair	Fair	.....	O. K.
17	Prob. rain	Prob. rain	Rain	Rain	.29	O. K.
18	Rain	Rain	Rain	Rain	.70	O. K.
19	Fair	Fair	Fair	Fair	.....	O. K.
20	Fair	Fair	Fair	Fair	.....	O. K.
21	Fair	Fair	Fair	Fair	.....	O. K.
22	Prob. rain	Prob. rain	Rain	Rain	.22	O. K.
23	Fair	Fair	Fair	Fair	.....	O. K.
24	Fair	Fair	Fair	Shower	.01	O. K.
25	Fair	Fair	Light shower	Shower	.01	O. K.
26	Fair	Fair	Light shower	Shower	T.	O. K.
27	Rain	Rain	Rain	Rain	.68	O. K.
28	Fair	Fair	Light rain	Rain	T.	O. K.
29	Fair	Fair	Fair	Fair	.....	O. K.
30	Fair	Fair	Fair	Fair	.....	O. K.

PEACH SPRAYING AND DUSTING

An extensive series of spraying and dusting experiments was carried out during the season. The early season was unfavorable for the development of brown rot and peach scab. Consequently all materials used controlled both diseases, and results are considered negative. Another attempt was made to control *Bacterium pruni* by spraying. The materials used were sodium silica fluoride with and without sulphur. No control was obtained. These combinations were tried because of some favorable preliminary reports from another state. Rarely does a bacterial disease respond to spray treatment and this disease does not seem to be an exception.

DAMPING-OFF OF CONIFEROUS SEEDLINGS

The control of damp-off of coniferous nursery stock has been investigated for the past three years. This disease is an important factor in the profitable production of coniferous seedlings in most forest nurseries. The fact that the fungi causing damping-off are soil inhabiting parasites, makes seedbed treatment imperative. Formaldehyde, sulphuric acid, sodium acid fluoride, sodium silico fluoride, and a number of organic mercury compounds have been tested. A brief summary of the data obtained from the experiments is given in the following table.

TABLE 14.—Summarizing Data on Control of Damping-off of Coniferous Seedlings

Material used	Total plants in plot	Damped off	Control over disease in checks	Year
	No.	*Percent*	*Percent*	
Sulphuric acid	805	31	28	1924
Check	720	43		
Sulphuric acid	112	10	50	1925
Check	101	20		
Sulphuric acid	89	24	17	1926
Check	120	29		
Formaldehyde	910	13	70	1924
Check	720	43		
Formaldehyde	41	0	100	1925
Check	286	90		
Formaldehyde	1,283	1.5	95	1929
Check	1,648	22.0		
Sulform	885	8.5	80	1924
Check	720	43.0		
Uspulun	745	17	60	1924
Check	720	43		
Uspulun	220	12	—33	1925
Check	286	9		
Uspulun	85	40	—38	1926
Check	120	29		
Semesan	895	15	65	1924
Check	720	43		
Semesan	197	2	78	1925
Check	286	9		
Semesan	110	12	40	1926
Check	101	20		

In addition to the materials listed in the table, Kalimat, Abavit, Wa Wa Dust, and Colloidal copper hydroxide were used. These materials did not control damp-off. The fluorides were toxic to the seeds. Formaldehyde gave the most satisfactory results of any of the materials tested. Under the conditions of the experiments the organic mercury compounds used did not control the disease satisfactorily.

SPRAYING AND DUSTING POTATOES

The spraying and dusting experiment on potatoes yielded striking results. A freshly mixed dust consisting of 20 parts monodehydrated copper sulphate and 80 parts of hydrated lime proved effective for the control of the hopperburn disease, which is the most destructive disease of the potato in Ohio that yields to treatment in the form of spraying or dusting. The control of hopperburn is responsible for the increases reported in the following experiments:

TABLE 15.—Results of Spraying and Dusting Potatoes

Treatment	Yield per acre bushels	Increase over comparable checks bushels
Experiment farm, Wooster, 1926		
4-4-50 bordeaux	233.5	70.1
5-5-50 bordeaux	244.1	73.8
4-6-50 bordeaux	244.1	63.8
Copper stearate dust	184.1	13.7
New York insect dust	264.6	80.7
Fresh mixed copper-lime dust	284.8	118.6
Green farm, Hiram, Portage County, 1925		
Check, no treatment	215.7	.....
Spray, bordeaux	287.2	71.5
Dust, fresh mixed	305.6	89.9
Dust, commercial mixed	270.8	55.1
Ryder farm, Hiram, Portage County, 1925		
Check, no treatment	152	.....
Dust, fresh mixed	200	48
Dust, commercial mixed	181	29

All treatments with the exception of copper-stearate dust gave substantial increases. After calculating the odds by Dr. Love's modification of Student's method that one treatment is better than another, it is concluded that the three liquid bordeaux treatments should be interpreted as being equal. The odds are 81.6 to 1 that the New York Insecticide dust gave a significant increase over liquid spray, 9999 to 1 that fresh mixed copper-lime dust gave better results than liquid spray, and 122 to 1 that fresh mixed dust gave better results than New York Insecticide dust.

Fresh mixed copper-lime dust for the past two seasons has proved superior to either commercial mixed dust or liquid bordeaux mixture for the control of the potato hopperburn disease. It is also significant to note that it can be prepared for one-half the cost of commercial mixed copper-lime dusts.

FURTHER STUDIES WITH POTATO DEGENERATIVE DISEASES

Many times a few rows of badly "run out" potatoes are planted to finish a field planted with disease-free seed from which certified seed or at least the grower's seed for the next year is to be saved. This is a bad practice and should not be tolerated in the production of certified seed. The degenerative diseases spread rapidly from a source of infection, and such a practice supplies the source. In an experiment in 1926, 50 percent of the plants (all of which were healthy at the beginning of the season) in a row adjacent to a row of rugose mosaic potatoes became diseased, and one plant out of every twelve became diseased in the seventh row from the mosaic row. The number of insect carriers of the viruses of degenerative diseases also has a bearing on their spread, the dissemination of the viruses being directly proportional to the number of insect carriers and inversely proportional to the distance from the source of inoculum. The conclusion is that seed fields should be isolated as far as possible from all other potatoes.

Weights of healthy hills and hills affected with leafroll, in the experiment, showed that the diseased hills yielded only 50.4 percent as much as healthy hills.

TOMATO STREAK, OR WINTER BLIGHT

This disease, which was formerly thought to be caused by a bacterium, was found to be due to a double mosaic. In the course of the year several thousand tomato plants were inoculated with a mixture of tomato and tobacco mosaic and a large percentage became streaked. Likewise the disease could be produced by inoculating with a mixture of tomato mosaic and juice of apparently healthy potato leaves. In all this work no bacterium was found to be connected with the disease.

The disease has become quite a factor in the production of both greenhouse and outside tomatoes. The source of infection may be in the seed bed or in neighboring weeds. If any of the plants become infected in the seed bed the disease may be spread rapidly by transplanting, cultivating, and pruning. The best control method so far worked out is to thoroly sterilize the seed bed with steam or, if steam sterilization be impossible, to use a 5-percent formaldehyde solution. Solonaceous weeds, such as ground cherry and horse nettle, should be destroyed. Tomatoes should not be planted adjacent to potatoes unless certified potatoes are used for seed. Fertilizers and spraying have no effect on checking the disease.

STEAM STERILIZATION OF GREENHOUSE SOILS

A study of the temperatures actually obtained at different depths under commercial conditions has been made in several vegetable greenhouses near Cleveland. The buried-tile, pan, harrow, and buried-pipe methods have been under observation. It was found that two important factors which determine depth of penetration of the steam in a given time under any of these methods, are the friable condition of the soil and its moisture content. Much better penetration was obtained in soils with less than 28 percent moisture than in soils with more. Better penetration was also obtained in soils which were stirred and the clods thoroly broken before steaming. The harrow method was found much inferior to the pan on heavy, wet clay.

NEMATODE CONTROL

During the last three years an attempt has been made to free greenhouse soils of nemas by the use of chemicals. In the tests all the chemicals thought possible of having nemacidal value were tried. Two types of checks were employed, one without treatment and the other thoroly steamed. None of the plots treated with chemicals gave satisfactory control. Steam only was successful. There were two reasons for making this elaborate experiment. The first was that soils thoroly steamed may not be as productive; the second, that certain chemical materials of questionable value were being highly recommended as nemacides. These materials were included in the experiment and proved worthless as controls for nemas. Only one chemical gave even slight control and that was cyanide. In conclusion, we do not recommend chemicals for nematode control.

EARLY CABBAGE RESISTANT TO YELLOWS

This project is strictly in the interest of truck growers in sections of the State where attention is given to the production of early cabbage. The yellows disease has seriously threatened the cabbage industry, even as it did the growing of late cabbage fifteen years ago. The strain of early cabbage selected three years ago has continued to maintain a high degree of resistance when grown upon soil on which ordinary commercial strains could no longer be raised with profit.

While the resistant selection appears to be a few days later in maturing than commercial strains that have been especially select-

ed for earliness, it is quite uniform in rate of growth and maturity, altho a considerable number of different types may be distinguished in the trial plots. The degree of resistance of the selection is shown by the following tests conducted by different growers upon diseased soil.

TABLE 16.—Result of Tests With Resistant Strains on Diseased Soil

Number of test	Resistant selection		Commercial strain	
	Number of plants	Percent diseased	Number of plants	Percent diseased
1	1,080	0.0	1,101	37.3
2	423	0.7	646	22.4
3	248	2.8	267	22.8
4	75	1.3	73	39.7
5	522	0.0	519	14.8
6	172	0.0	173	46.8
7	184	1.1	169	39.6
8	318	0.9	292	72.6
9	600	0.6	All dead, no count	100.0

CELERY BLIGHT CONTROL

Experiments were conducted in widely separated celery fields in the State during the season of 1926 for the purpose of ascertaining, if possible, the relative efficiency of several different sprays and dusts in controlling celery blights.

There are two blights of celery common in Ohio. Early blight, caused by *Cercospora apii*, is common but seldom seriously injures the crop since it is confined to the leaflets and is checked by cool weather. Late blight, caused by *Septoria apii*, is also wide spread but much more destructive than the *Cercospora* blight since it affects the whole plant and persists at rather low temperatures.

The first half of the celery growing season (until about August 10) was too dry for either of these blight forms to become serious, altho scattered points of infection were frequently observed in nearly all fields. The latter part of August and all of September and October were very wet. Thru August and September while the weather remained warm, early blight spread rapidly and became quite serious in some fields. During October late blight, which had been spreading constantly in September, became serious and nearly ruined many fields, some of which were so soft from excessive rainfall that spraying and dusting machines could not be used.

However, the experimental plots were treated as per schedule, by the use of hand dusters and sprayers. The following table shows the treatments, the location of the plots, and the results.

TABLE 17.—Average Number of Blight Spots per Plant

Place	Treatments					
	Check	5–5–50 bordeaux spray	Colloidal-copper spray	Copper-stearate dust	20–80 copper-lime com'l dust	20–80 copper-lime home mixed dust
Cleveland, late blight	2,974	323	1,385	652	469	.....
Willard, early blight	250	almost none	.....	224	197	175
Average weight per plant in pounds						
Willard, early blight	.57	.....	.....	.54	.56	.57
Shreve, early and late	.74	.....	.....	.96	1.65	1.61
Ravenna late blight	.67	.73	.....	.....	.77	.82

*This plot least infested with celery leaf-tyer, thus seemingly high yield.
1. weight without roots; 2. and 3. weight with roots.

The results in the columns headed "spray" are of little value except in the Cleveland experiment, due to irregular applications.

When the number of diseased spots per plant are considered, it is seen that the sprays were very efficient in controlling blight, and also that copper stearate, which was difficult to apply by the means at hand, did not give good control.

TABLE 18.—Results of Trials of 1926

	Preparation	Percent smut
	Check, not treated	19.0
1	Colloidal copper	6.6
2	Wa Wa dust	0.004
3	Mercuric chloride 2 parts; Copper sulphate 1 part	Trace
4	Mercuric chloride, Cresylic acid, Copper sulphate — equal parts	None
5	Mercuric chloride, Phenol, Copper sulphate — equal parts	0.9
6	Copper sulphate, Oil of wintergreen absorbed by inert carrier — equal parts	6.0
7	Copper sulphate, Cresylic acid — equal parts	2.4
8	Copper sulphate, Phenol — equal parts	1.8
9	Formaldehyde (1–80)	None

There was but little difference in the effectiveness of the commercial and home-mixed copper-lime dusts, both giving good control.

In spite of the season which was unfavorable for the host and advantageous for the blight organisms, the treatments gave substantial yield increases over the checks.

CONTROL OF OAT SMUT

Altho the dusts used for the control of oat smut in the tests of 1924 and 1925, reported in Ohio Agr. Exp. Sta. Bul. 390, gave excellent control, they are expensive to prepare, costing about $1.50 per pound.

Further tests were conducted during the season of 1926 for the purpose of finding a cheaper dust of equal fungicidal efficiency. Some of the preparations tested show considerable promise, yet further trials must be made for confirmation of the results of this year. See Table 18.

All of these mixtures were prepared for use as dusts. An inert filler was infiltrated with the phenol and oil of wintergreen.

CONTROL OF STINKING SMUT OF WHEAT

The results of experiments conducted at Wooster for the control of stinking smut or bunt of wheat by the use of dust treatments have not always agreed with similar experiments carried on at Columbus. The object of the series of tests begun in the fall of 1925, was to determine, if possible, the reason for the discrepancies in the results of previous years, and to endeavor to obtain a uniformity of control, which would serve as a basis for future recommendations.

TABLE 19.—Results of Seed Treatments for Control of Stinking Smut of Wheat

Preparation	Percent smut at Columbus	Percent smut at Wooster
Wheat treated at Columbus		
Check, untreated	14.6	41.7
Copper sulphate+lime 3 oz. (anhydrous)	Trace*	0.4
Copper carbonate pure 3 oz.	Trace	0.45
Copper carbonate pure 2 oz.	Trace	0.2
Semesan, 13 U. A. 2 oz.	5	1.4
Semesan dust, 2 oz.	0	1.5
Wa Wa dust	Trace	0
Bayer dust	1.93	0.6
Corona copper carbonate 2 oz.	1.75	0.22
Corona copper carbonate 3 oz.	.3	0.5
Wheat treated at Wooster		
Check, new wheat untreated	41.7	14.6
Year-old wheat untreated	41 1	.....
Copper carbonate pure3 oz.	0.5	Trace
Copper carbonate pure 2 oz.	0.46	Trace
Corona copper carbonate 3 oz.	0.42	0.1
Corona copper carbonate 2 oz.	0.03	Trace
Bayer dust, 2 oz	0.3	0.1
Semesan dust, 2 oz.	0.4	0.3
Sanders dust 8.5% copper 3 oz.	0.68	2.3
Sanders dust 6.5% copper 3 oz.	0.87	.....
Copper stearate 1 oz. per bu.	0.8	2.58
Copper stearate ½ oz. per bu.	0.0	.....
Copper stearate ¼ oz. per bu.	0.9	.....
Du Pont No. 37, 3 oz.	14.6	.....

*Trace=less than one-tenth of 1 percent.

The same lot of wheat was used for all tests. A portion of the wheat treated at Wooster was retained for planting on the Station farm while the remainder was sent to Columbus to be included in the tests there. A portion of the wheat treated at Columbus was kept for tests there, while the remainder was sent to Wooster. The plots at Wooster were sown October 16, and those at Columbus October 27. The results are shown in Table 19.

CANADA THISTLES AND HERBICIDES

Thru the study of thistles grown in the greenhouse as well as those in the field, information was obtained concerning the morphology, variability, life history, and insect and fungous enemies of the plant. During the summers of 1925 and 1926 five herbicides were used, namely, sodium and calcium arsenites, Atlas weed killer, Nitre cake, and sulphite of soda. Of these, calcium arsenite was the most efficacious. The results show that the use of chemicals, due to their high price and the cost of application, is not to be recommended for large thistle infested areas, but that calcium arsenite can be satisfactorily used when other measures are not feasible.

STUDIES IN PARASITISM

An investigation was conducted to determine the availability of the quinhydrone electrode for use in connection with studies of the nature of the resistance of certain tomatoes to Fusarium wilt. The use of the quinhydrone electrode for electrometric determination of

TABLE 20.—The Use of Quinhydrone, the Hydrogen Electrode, and Indicator Dyes in the Determination of the pH Values of Some Plant Juices

	Q. H.	H. E.	Colori metric	Q. H.	H. E.	Colori metric	Q. H.	H. E.	Colori metric
	Cabbage			Bean			Potato		
pH	6.72	6.49	6.4	5.79	5.64	5.6	6.06	5 92	6.0
pH	6.62	6.22	6.2	5.78	5.62	5.6	6.01	5.21	6.0
pH	6.65	6.32	6.4	5.77	5.60	5.6	5.99	5.94	.....
pH	6.70	6.50	6.4	5.82	5.68	5.6	6.0	5.98	6.0
pH	6 68	6.42	6.4	5.81	5.67	5.6	.....	.....	.....
Dye	.....	.....	BCP	.....	.....	.....	.....	.....	BCP
	Tomato			Rumex crispus			Malva alcea		
pH	5.54	5.53	5.5	3.70	3.68	3.7	6.99	6.70	6.8
pH	5.55	5.51	.....	3.72	3.68	3.7	.....	.....	.....
pH	5.52	5.50	.....	3.69	3.67	3.7	.....	.....	.....
pH	5.58	5.52	5.5	3.70	3.69	3 7	.....	.....	.....
pH	5 59	5.51	.....	.....	.....	.....	.....	.....	.....
pH	5.61	5.51	5.5	.....	.....	.....	.....	.....	.....
pH	5.54	5.51	5.5	.....	.....	.....	.....	.....	.....
Dye	.....	.....	BCP	.....	.....	BPB	.....	.....	BTB

the H-ion concentration and the titratable acidity of plant juices has been investigated to some extent. The data secured from the preliminary experiments suggest that the quinhydrone and the hydrogen electrodes will give nearly the same pH values on comparable samples of some plant juices but not on others. The results of the tests so far made are summarized in Table 20. The colorimetric determinations were made by comparison with a color chart.

The curves obtained by titrating comparable samples of plant juice with the hydrogen and quinhydrone electrodes do not agree in most cases. However, there was fair agreement between the two when juice of *Rumex crispus* was titrated. It should be noted that the initial pH of the expressed juice of Rumex is low and that as neutrality exceeded the deviation between the curves increases. A few curves are shown in Figure 4.

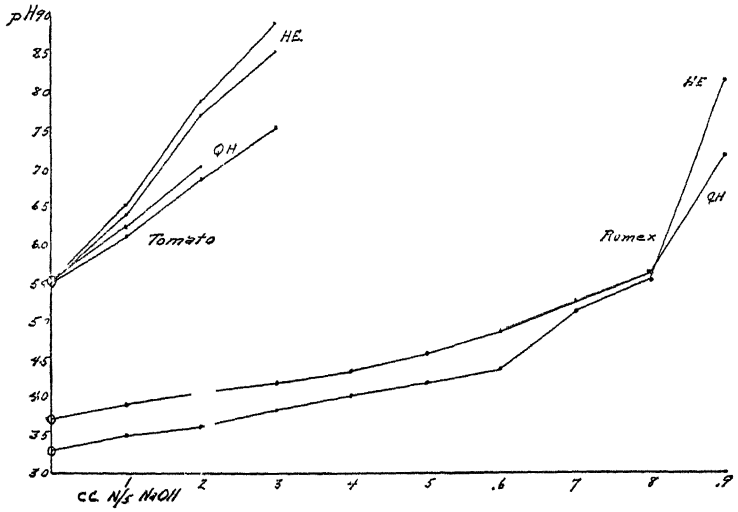


Fig. 4.—Titration curves of comparable samples of plant juice using the Hydrogen and the Quinhydrone Electrodes

Attention was first directed to the growth of *Fusarium lycopersici*, the cause of tomato wilt, in culture media in respect to changes in the hydrogen-ion concentration. In some artificial media this fungus is able to reduce the H-ion concentration and the media becomes more alkaline. It has been demonstrated that the growth of *F. lycopersici* reduces this medium's buffer capacity. The graph (Fig. 5) shows the titration curve of the uninoculated media and of the media after the fungus had grown in it 30 days.

Our work has shown that the hydrogen-ion concentration of resistant and susceptible varieties is about the same, so this factor is probably not the cause of resistance. Tests of diseased and healthy plants indicate that plants infected by *Fusarium lycopersici* are more alkaline than healthy plants. It would seem then that the fungus is able to alter the normal hydrogen-ion concentration of the juice and that the change is toward greater alkalinity. The plant can be regarded as a natural culture medium and it would not be illogical to suspect that the same conditions would prevail in it as occur in artificial culture media. The data secured thus far seem to confirm this view but a definite statement must be reserved until further data are secured to support that which is now at hand.

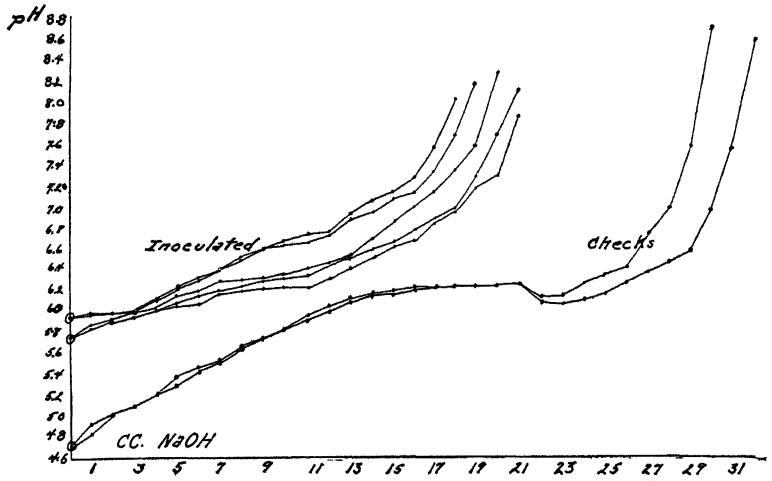


Fig. 5.—Titration curves of culture media showing the change in pH and in buffer action after a 30-day growth of *Fusarium lycopersici*

A few determinations of the titratable acidity of susceptible and of resistant varieties of tomatoes suggest that there may be sufficient difference between them to explain the cause of their behavior toward Fusarium infection. The titrations upon which this conclusion is based were made with the quinhydrone electrode whose reliability for the titration of plant juice has not as yet been established.

Some attention has been given to the chemical structure of fungous hyphae. Our present knowledge of this subject is only fragmentary. Many investigators have considered this a fruitful and legitimate field of investigation, but in a great majority of the cases results have been meager and on the whole disappointing. Nothing as yet of an economic nature has been forthcoming.

It is believed, however, that when the mystery of the structure of the cell walls of many of our serious parasites is revealed we will be enabled to apply fungicides for their control much more rationally and effectively. It is also reasonable to assume that a knowledge of the chemical structure of fungous hyphae will aid in understanding the metabolic processes involved and also, possibly, throw light upon the basic principles underlying the susceptibility and immunity of the host and the tendency towards parasitism on the part of the parasite.

In many of the mucors, cellulose can be readily demonstrated. It appears, however, to be mixed with pectic compounds. From this point of view their membrane seems to be more like that of the flowering plants and the vascular cryptogams. The reaction with iodine reagents, however, is for the most part characteristic for cellulose, altho at times the blue color is less intense. This is in marked contrast to cellulose of the Peronosperaceae investigated. In the case of the latter, callose is usually found to be associated with the cellulose, commonly forming an outer sheath or covering.

Much difficulty attends the analysis of fungous hyphae by attempting to detect and remove each layer in consecutive order thru the use of appropriate solvents. In many instances the extremely small quantity of material obtained renders definite confirmatory tests difficult to apply. Dyes are an aid in this respect but cannot be depended upon because frequently they are misleading.

ENTOMOLOGY

THE EUROPEAN CORN BORER

The study of the European corn borer was continued in 1926 as the chief project of the Department of Entomology. Due to the rapid increase in infestation in Ohio and the tremendous losses occasioned by the insect in Canada in 1925 the entire research program has been greatly accelerated. The Department of Agronomy has also greatly extended its field of investigations. Cooperative work with the Department of Agricultural Engineering has been continued. Thru the services of the Department of Botany of the Ohio State University, the Ohio Experiment Station was able to conduct certain ecological studies during the past summer. These studies were greatly facilitated by the generous cooperation of Canadian entomologists. Agronomists and entomologists of the United States Department of Agriculture have also contributed to the progress of certain phases of the work.

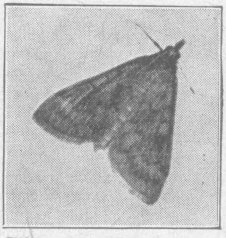


Fig. 6.—European corn borer moth (natural size)

The European corn borer increased enormously during 1926. In some sections of the State the increase amounted to about 500 percent. The damage in a few instances was serious. In at least one field where the borer population per stalk averaged ten, the loss was variously estimated from 25 to 40 percent. Harvesting of the crop was made difficult because of the many broken stalks, see Figure 9. Table 21 shows the condition of a few representative infested fields on or about September 15.

Fig. 7.—European corn borer larva (natural size)

Handling corn crop and residue.—The first suggested means of control of the corn borer involved the use of ordinary farm equipment. A study of the habits and behavior of the insect showed that more borers could be destroyed if certain farm equipment were redesigned or new and special machinery developed. The efficiency of all equipment is carefully checked by the entomologists before a recommendation is made.

Thru the cooperative efforts of the Federal Bureau of Entomology, the State Department of Agriculture, the Ohio State University, and the Ohio Experiment Station low-cutting attachments for corn binders have been perfected to the extent that they are

TABLE 21.—Infestation in Representative Fields in Corn Borer Area in Ohio, September, 1926

Field number	Borers per stalk	Stalks infested	Stalks detasseled	Stalks Broken
	No.	*Percent*	*Percent*	*Percent*
1	1.4	57	22	6
2	2.7	60	22	4
3	2.9	69	26	6
4	3.5	71	24	9
5	3.5	80	26	7
6	4.2	84	32	11
7	3.4	89	42	12
8	4.8	92	39	14
9	3.0	95	50	14
10	10.0	100	50	14

now being manufactured and offered for sale by commercial agencies. This attachment makes it possible to cut to within three inches of the ground, thus leaving very short stubble and consequently fewer borers in the field than when corn is cut by ordinary methods.

Records of 1923 indicated that as the season progressed the corn borer larvae moved downward in the stalks. The following table shows such larval migration from August 20 to September 10, 1926, in a single field in the Bono region.

TABLE 22.—Number and Position of Borers in Stalk at Different Dates

Date examined	Average borers per stalk	Below 6 inches	Below 12 inches	Below 18 inches	Below 24 inches
	No.	*Percent*	*Percent*	*Percent*	*Percent*
August 20	8	7	18	23	37
August 27	4	9	26	41	52
September 3	7	22	42	50	56
September 10	5	24	41	55	67

An analysis of these data will explain why it is better to cut corn as early as possible. At the same time they show that the longer corn is allowed to stand after it is mature the lower down the borers will be and the greater the number left in the stubble.

Agricultural Engineers are further cooperating by re-designing ensilage cutters and shredders and by the development of special harvesting machinery. Much of this work is still in the experimental stages.

One of the encouraging features of machinery development is the fact that the large machinery companies have taken upon themselves the task of producing equipment that will aid in the task of attempting to control the borer. A notable example of such action is the designing and manufacturing of a 16-inch or 18-inch bottom

plow by one of the larger plow companies. Plowing under stalks and high stubble is now recommended as an additional aid in the attempt to control the borer.

Disking standing stalks and high stubble is a very poor practice in any corn borer control program, hence should be discontinued at the earliest possible date.

Shredding the fodder destroys practically 95 percent of the borers that pass thru the shredder. Those that remain stand a poor chance of survival due to the subsequent handling of the fodder. Cutting infested stalks into short lengths of one inch or less destroys practically all borers.

When standing stalks are to be burned they should be broken or cut off and then raked two ways. If the raking and subsequent burning are carefully done the cleanup is fairly satisfactory.

Fig. 8.—A badly damaged hill of corn. Note the broken stalks

At the beginning of the investigational work in Ohio in 1923, it was suspected that mechanical measures alone might not insure the control of the borer. Investigations seem to bear out that suspicion. For example, part of field No. 10, Table 21, was cut the latter part of October with a corn binder equipped with a low cutting attachment. The remaining stubble measured about 3.5 inches. However, the stalks were so badly damaged by the borers that many of them broke off during the cutting process and fell to the ground. As a result about 12,000 borers per acre were left in the short stubble, debris and weeds that remained on the ground. There were about as many borers left in this field after the harvesting of the crop as there were in the entire crop in 1925. However, if no attempt had been made to clean up the remnants of the 1925 crop the losses in this section in 1926 might have been much great-

er. This is only an illustration of one of the facts that has led to the conclusion that, while mechanical measures must play an important role, they nevertheless have their limitations. Biological and ecological evidence appears to corroborate these conclusions.

Fig. 9.—Corn infested with European corn borer

Above, a heavily infested field in Canada. This field had an average of more than 30 borers per stalk. The crop was an entire loss.

Below, a heavily infested field in Lucas County, Ohio. This field had 100 percent stalk infestation and an average of 10 borers per stalk.

In anticipation of this eventuality the agronomic phases of the corn borer project were greatly enlarged in 1926.

The varietal and seasonal-planting experiments, begun in 1923 at Geneva in Ashtabula County and continued since at Bono in

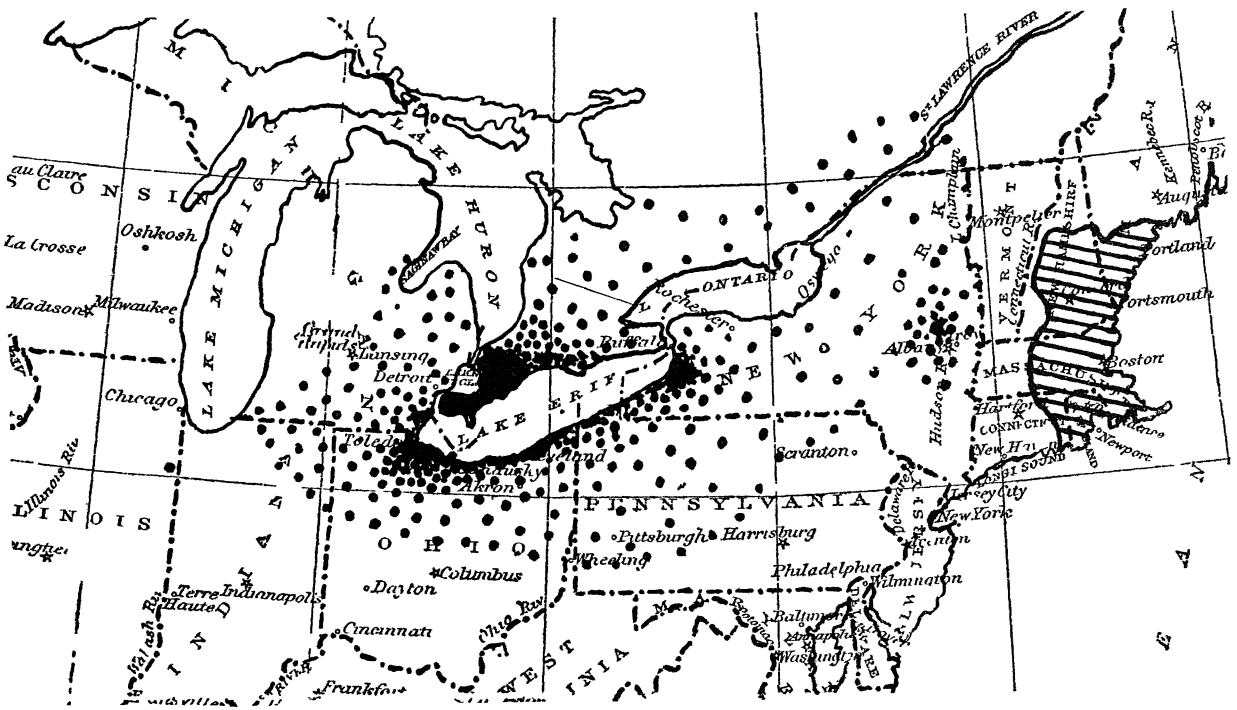
Lucas County and at Paulding in Paulding County, were extended to Wayne and Hamilton Counties in 1926. The main series of plantings was at Bono, Lucas County, in the center of the most heavily infested area in Ohio. The plantings at the other places were similar in general plan altho less extensive in total acreage and in number of varieties.

It is, of course, understood that these plantings have two main purposes. It was desirable first of all to know how late it is necessary to plant corn in order to avoid serious damage; second, to know the relative ability of different varieties to tolerate borer attack; and third, in addition to these objectives, to obtain data relative to the yield of a number of representative varieties when planted at different dates. The discussion of the agronomic phases, therefore, will hinge about these three points.

Date of planting.—At Bono the plantings were increased this season from twelve to fourteen varieties, eleven of field and three of sweet corn. The first planting was made May 1 and the last on June 20. At Paulding six varieties of field corn were planted, beginning May 10 and continuing at ten-day intervals to June 20. Similar plans were followed at Wooster and Hamilton. The varieties tested on the different farms were selected to meet the requirements of local conditions. The plantings made at Sandusky in 1924 and 1925 in cooperation with the Federal Bureau of Entomology were discontinued.

The graph on page 64 illustrates the difference in the degree of infestation for different planting dates. The infestation at Geneva in 1923 was so small that it is not included here. A study of this graph indicates that corn planted from May 10 to June 1 is likely to carry a rather heavy infestation as compared with corn planted later. But what is still more significant than the stalk infestation is the borer population per infested stalk. For example, it has been observed that even tho late planted corn has a considerable number of stalks infested the number of borers in these stalks is so small that little loss occurs. Large borer population per infested stalks occurs only in corn planted early. The uppermost line in the graph represents the actual borer population while the one immediately below indicates the stalk infestation in the 1926 plots.

Variety tolerance.—It has been mentioned in previous reports that no known variety is free from corn borer attack. Due to greater vigor or size some varieties can withstand borer attack



This map shows the present distribution of the European corn borer. In the dotted area there is one generation per year while in the barred area there are two generations per year. Note the intensity of the infestation around Lake Erie. Beyond the solid black area adjacent to the Lake no commercial damage has resulted

better than others; but when the infestation is high, corn planted early or on the normal date is severely damaged despite its size.

Yield records were taken at each of the stations. The comparative average yields of all varieties for each planting date in 1924 and 1925 are indicated in Tables 23 and 24.

TABLE 23.—Yield of Shelled Corn* for Normal and for Last Planting Dates

Variety	Bono		Sandusky		Paulding
	1924 Bu.	1925 Bu.	1924 Bu.	1925 Bu.	1925 Bu.
Normal planting date†					
Reid's Yellow Dent	51.6	.....	52.0	.....	.....
Burr Learning	62.4	116.5	51.7	50.4	79.5
Leaming	.....	96.6	47.1	43.8	73.6
Clarage	48.7	94.1	40.7	43.0	73.3
Ohio Selected low percent grain	46.7	90.3	41.6	.....	.....
Van Wye	43.8	83.3	.....	35.1	.....
Ohio Selected low ear	.....	.....	.....	29.6	49.6
Golden Glow	.....	77.5	.....	34.6	73.6
Silver King	46.7	.....	41.0	.....	62.2
N. W. Dent	40.9	49.7	16.1	.....	.....
Stone's Calico	.....	.....	46.0	.....	.....
White Cap	.....	.....	.....	.....	70.3
Last planting date‡					
Reid's Yellow Dent	30.7	.....	29.9	.....	.....
Burr Learning	47.5	74.6	34.9	37.2	56.4
Leaming	36.7	70.1	38.0	33.5	62.7
Clarage	32.0	67.6	34.2	33.2	63.4
Ohio Selected low percent grain	34.6	57.3	33.9	.....	.....
Van Wye	26.7	68.0	.....	34.0	.....
Ohio Selected low ear	.....	.....	.....	31.9	48.0
Golden Glow	.....	74.9	.....	33.2	65.5
Silver King	28.2	.....	38.5	.....	56.3
N. W. Dent	24.0	48.9	13.3	.....	.....
Stone's Calico	.....	.....	39.5	.....	.....
White Cap	.....	.....	.....	.....	56.2

*Air dry in 1924; reduced to 15½ percent moisture in 1925.
†Average of first two planting dates May 8, 9, or 10 and May 19 or 20.
‡June 19 or 20 at Bono and Sandusky; June 10 at Paulding.

Rate of planting.—In order to determine the preference of moths for corn planted thick or thin a rate-of-stand experiment has been in progress since 1924. The rate of planting has ranged from one to six plants per hill. Thus far no conclusive results have been obtained.

Fertilizer tests.—Observations prior to 1926 indicated that late planted corn is damaged less than corn planted at the normal date. Certain fertilizer experiments were, therefore, started by the Department of Agronomy in 1926 to determine the extent to which fertilizers might be used to increase the yield and hasten the

maturity of late planted corn. The experiments involved the comparison of different kinds and amounts of fertilizers and different distributions between broadcast and hill applications upon corn planted at the normal date, May 15, and at a late date, June 5. The tests were carried on at Bono and Wooster. At the present time it appears that the variations in soil and weather may greatly influence the results to be secured from the use of fertilizers in hastening the development of corn. While the results of one year's work can not be conclusive it may be said that the results at Wooster were encouraging but those at Bono were not. Further investigations are necessary.

TABLE 24.—Maturity of Late Planted Corn* as Indicated by Percentage of Shrinkage or Moisture†

Variety	Bono		Sandusky		Paulding
	1924	1925	1924	1925	1925
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Reid's Yellow Dent	44.5	.....	57.0	.....	.....
Burr Leaming	41.0	39.7	53.0	54.6	43.7
Leaming	39 5	39.3	49.0	55.0	37.6
Clarage	32.0	35.3	45.5	49.8	31.1
Ohio Selected low percent grain	33.5	33.6	45.5	.....	.....
Van Wye	27.5	28.0	.....	41.2	.....
Ohio Selected low ear	.....	.....	.....	40.4	25.1
Golden Glow	.....	34.2	.....	39.4	35.8
Silver King	30.5	.....	40.5	.....	31.3
N. W. Dent	23.0	29.4	36.0	.....	.....
Stone's Calico	.....	.....	32.5	.....	.....
White Cap	.....	.....	.....	.....	33.3

*Planted June 19 or 20 at Bono and Sandusky and June 10 at Paulding.
†Data for 1925 represents shrinkage under dry storage from husking time until spring. 1926 data represents moisture content at husking time.

Corn breeding.—As already mentioned, it has been shown that corn must be planted much later than customary if it is to escape a high percentage of infestation. This means that the variety of corn must make its growth and development in a shorter period of time than is now the case if equal or satisfactory yields are to be secured. The vigor necessary for this intensive development can be secured only by using first generation hybrids between two or more pure lines (single or double crosses). By choosing the right pure lines for the cross any degree of earliness or lateness may be secured. Corn breeding in relation to the corn borer, therefore, consists largely in developing varieties which will fit into such changes in farming practices as may be necessary because of the advent of the corn borer and which will still produce the highest possible yields under infestation conditions.

In order to unify the assembling and testing, under corn borer conditions, of the material that resulted from corn breeding investigations prior to the advent of the borer the Ohio State University; the United States Department of Agriculture, Bureau of Plant Industry, and Bureau of Entomology; the Ontario Department of Agriculture; the Dominion Bureau of Entomology; and the Ohio Agricultural Experiment Station are cooperating. Corn breeders of twelve states have generously contributed for testing what they consider their best inbred lines and crosses. The breeding investigations prior to the advent of the borer the Ohio State University; Columbus.

In cooperation with Canadian entomologists a special series of plantings was conducted in the center of the heavily infested area in Ontario. Eight varieties, each planted in triplicate on three planting dates, constituted the test. Four of the eight were F^1 hybrids. Ordinary varieties were used as checks. A careful study of these plantings by Canadian and Ohio entomologists showed a considerable difference in the ability of some varieties to tolerate borer attack. A great number of hybrids and pure lines were also included in the Bono plantings.

Areas of infestations.—One of the outstanding and notable observations relative to the behavior of the corn borer is that it has shown a tendency to accumulate in various parts of the State. For example, certain areas in northwestern Ohio are heavily infested as compared with other areas. This condition also obtains in Pennsylvania, Michigan, New York, and elsewhere. Reference to the map on page 54 will indicate the difference in degree of infestation in various parts of the State.

Forest type regions.—Preliminary evidence indicates that there might be a correlation between certain vegetative types and the degree of infestation by the insect. The Ohio Station thru the services of Drs. E. N. Transeau and H. C. Sampson, of the Ohio State University, made a survey of the infested regions of Ohio, Michigan, Canada, and New York, the purpose of which was to attempt to find an ecological index to the degree of infestation. This work is still incomplete, but such evidence as has been collected indicates that there is a close correlation between the distribution of certain forest types and the accumulation of the corn borer. The survey in Canada was facilitated by the cooperation of Canadian entomologists to whom great credit is given. The map indicates the extent of correlation between forest types and insect infestation in Ohio.

Relative to the influence of humid conditions on the behavior of the insect it is of interest to note that the area where most serious damage has occurred in Ohio is in the vicinity of Bono. Many acres of this particular region are below the level of Lake Erie and consequently are known as "pump lands", due to the method of drainage. This observation is in line with the correlation between forest types and infestation.

Related species.—In connection with the ecological survey it is of interest to mention that the nearest relatives of the European corn borer, in point of resemblance or morphology, are the Smartweed borer, the Lotus borer and the Dogbane borer. All of these three relatives, like the corn borer itself, are best adapted to swamp-like regions where there is a constantly high humidity.

Temperature and humidity.—Certain artificially controlled and field experiments in 1925 indicated that excessive drought was inimical to normal larval behavior and development. The failure of the insect to increase to the extent expected in 1925 was undoubtedly due in large measure to the excessive heat and drought during the months of May and June. Larvae in infested stalks stored, as in barns, where they received no moisture either shriveled up and died before the moths could emerge from the dry stalks or the moths emerged at a very late date. Moths that emerge at abnormally late dates are considered negligible. Corn or corn fodder in dry storage, therefore, is not considered an important source of reinfestation in Ohio.

Further experiments this year indicate that the moths live longer and deposit more eggs under conditions of high humidity than low humidity. This additional fact further explains the failure of the insect to make a great increase in 1925, while the opposite or favorable conditions of humidity this year are held as the reasons for the tremendous increase of 500 percent in 1926.

Physiological studies.—The physiology of the corn borer has been facilitated by the initiation of the study of the physiology of the corn plant, its host. The heavier infestation of early planted corn is, of course, due to the fact that more moths are attracted to the earlier corn than to the later corn. It is desirable to know, first, what attracts them and, second, to what advantage may the information be used after it is obtained.

Plant physiologists of the Department of Agronomy are actively assisting in investigating the nature of the attractant. It has been experimentally demonstrated that extracts from corn planted early are different than those from corn planted late. Repeated

tests with moths indicated that the moths had little difficulty in detecting the difference between the extracts. The next task in this connection is to isolate the attractant, if possible, and to determine whether or not it may be in any way manipulated by corn breeders.

Morphological studies.—Parallel to physiological studies are those pertaining to the structure or morphology of the plant. Certain morphological studies have been in progress since 1924. The scope of this phase of the problem, however, was greatly enlarged in 1926. It has been established that certain morphological characters greatly influence the behavior of the moths. An attempt is being made to modify certain characters in the hope that they will prove inimical to larval development.

In connection with the physiological and ecological studies mentioned above, an attempt is being made to discover the underlying factors which so greatly influence the behavior of the corn borer. It has been stated that there is a correlation between vegetative types and accumulation of the insect. The correlation is still unexplained, altho, from the results of the physiological experiments, it would seem that humidity and temperature are the important factors. A project attempting to evaluate humidity was begun in cooperation with the Department of Botany, Ohio State University, and Mr. Neale Howard, in charge of Mexican bean beetle investigations, Federal Bureau of Entomology. A total of more than 100 atmometers have been set up at what is considered strategic points over the State. It is hoped that these atmometers will yield data relative to the rainfall-evaporation ratio.

By way of conclusion it may be stated that it is the feeling of all the agencies concerned that the cooperative efforts of the past year have resulted not only in a distinct advance in our knowledge of the behavior and habits of the insect but also in a more complete appraisal of possible methods of defense. However, despite the progress, it must be admitted that a great deal remains to be discovered if we would control this insect. It is obvious that in proportion as the entomologists discover new facts relative to the insect the workers in allied fields can proceed more intelligently with their respective tasks. Moreover, it is even possible that future biological studies may open up entirely new fields of attack for allied investigators. It seems quite apparent that the various phases of the project are interdependent and that the most rapid progress can be made only thru continued cooperative efforts.

CORN INSECTS

The advent of the European corn borer has stimulated an interest in the subject of corn insects in general such as had not previously existed. There is a constantly recurring demand for information, particularly concerning insects that resemble the European corn borer and attack the plant in much the same way. However, other corn insects, such as sod webworms, which were unusually prevalent this season, have attracted attention. As a result it seemed appropriate to begin a rather extensive project on corn insects as a whole. An exhaustive canvass of the literature of the subject has been made and a philosophical paper on the origin of corn insects prepared. This paper, which furnishes a setting for the project, probably will be published this coming year.

LEAF HOPPERS INFESTING APPLE

Several species of leaf hoppers that infest apple overwinter in the egg stage. These eggs are inserted in the twigs of the tree and lie just under the bark. Their position can be recognized by a slight oval, swollen area. Some work has been done by various experiment stations with sprays designed to kill these eggs. At the time of the delayed dormant spray in 1926 a large series of sprays were applied to trees at Wooster and at Chardon, Ohio. These sprays consisted mostly of oils, oil emulsions, lime-sulfur, bordeaux mixture, and various combinations of the same. Just as the last eggs were hatching counts were made on the foliage of the trees in the various plots. The number of living nymphs on a given number of leaves from the check plot was considered as representing the normal hatch. Practically all the materials gave a lower percentage of hatch than the check. In the case of the oil sprays and some of the combinations in which oil was used the hatch was reduced as much as 50 percent.

APPLE APHIDS IN OHIO

During the winter of 1925-26 examinations showed that the eggs of aphids on apple were unusually scarce. In the northern sections of the State none could be found. An analysis of the temperature data for several preceding years showed that the absence of aphid eggs was due in large part to the low temperatures prevailing during the period of autumn migration and oviposition. In 1925 the mean temperature for this period averaged more than five degrees below normal, thus curtailing the activities of the aphids to this marked extent.

In spite of the absence of aphis eggs it was thot best to follow our experimental spray program as usual. The various oils, lime-sulfur, nicotine, etc., were, therefore, applied on an extensive series of plots. This was without result as the absence of eggs prevented the start of any outbreak. In southern Ohio in one or two dusted orchards there was an outbreak of rosy apple aphis in June. However, there was little commercial damage. The green apple aphis was very rare until early August, when outbreaks on young trees occurred in several sections of the State.

THE CODLING MOTH

Due to the increasing severity of codling moth, experimental work with this insect was resumed.

Biological data, with especial reference to the date of applying the midsummer cover spray, were collected at Wooster and at Oak Harbor. The first larvae left the apples at Wooster on July 8, but large numbers were not noted till July 18. The first moths appeared on July 24 but the emergence was not significant till July 30. At Oak Harbor the first larvae appeared on July 6 but large numbers were first noted on July 18. The first moths were collected on August 30, with significant numbers first appearing on August 7. The data from these two points show that the usual date of the midsummer spray in northern Ohio (July 20) would have been at least two weeks early.

In 1925 some orchards near Delaware, Ohio, were severely infested and a large percentage of the crop lost due to worms. One of the orchards suffering this loss was ideal for experimental work and with the cooperation of the owner, E. L. Main, an extensive experiment was carried out during the summer of 1926.

Three applications of spray according to the usual recommendation for codling moth control were applied. Five applications of dust were made to the plots under this treatment. The results showed that dust in this experiment was not as effective as spray. Oil used as an ovicide was ineffective; one grade of manganese arsenate brought about little control; and the same was true of colloidal arsenate used in low strengths. The difference between other materials and combinations were not great enough to warrant conclusions, based on one year's experiment. The entire experiment was in cooperation with the Department of Botany, representatives of which took records on diseases present. The check trees showed approximately 85 percent of the fruit injured by worms.

THE POTATO SCAB GNAT

The potato scab gnat, *Pnyxia scabiei*, became an important pest of the potato crop in 1926. The larvae of this gnat feed on the tuber; first on the seed piece and later on the tubers of the current crop. They have also been found feeding on and boring into the stems of the plant below the surface of the ground.

When the seed potato was attacked the fleshy part often was found to be almost entirely consumed, leaving little besides the skin from which the sprout could draw its food supply. This resulted in a poor stand and many weak plants. The injury to the current crop varied from slight abrasions of the skin to the destruction of a large part of the tuber, rendering many of them unfit for market. The injury done by this insect may easily be confused with that done by white grubs or wireworms, and in its early stages the injury may be mistaken for potato scab. In some of the fields examined 60 percent of the potatoes were found to be injured.

The distribution of this insect appears to be quite wide within the State. The insect was taken in Tuscarawas, Stark, Portage, Geauga, Summit, Erie, Huron, Allen, Morrow, Ashland, and Wayne Counties. It has also been reported from Cuyahoga County, and potatoes showing signs of the insect's activities were brought to the Station from Hamilton County. The infestation appeared to be most severe in Erie, Huron, Allen, and Auglaize Counties.

The insect is being closely observed and its life history and habits are being studied. According to the reports of some of the growers this insect has been increasing for the last three or four years and if it persists in the future in proportions even less than it appeared in 1926 it will justify no small amount of research.

THE BEAN APHID

An outbreak of the bean aphid, *Aphis rumicis*, developed in Pickaway, Fayette, Fairfield, and Ross Counties in 1926. In this section hundreds of acres are planted to Lima beans annually, the crop being utilized by the canning industry. An outbreak of lesser importance was reported from Coshocton County. The loss was evidenced not only in the reduced yield, but a crop of uneven quality was produced. The canning industry requires a uniform quality of beans, which involves both size and degree of ripeness, and, unless this is obtained, the canners must employ a large amount of labor in culling the beans. Inferior quality is reflected in a greatly reduced price paid to the growers. Early Henderson Bush Limas are grown almost exclusively and the losses were confined to this variety.

In a series of experiments conducted at Circleville it was shown that almost perfect control could be effected by the use of 1.6 per cent nicotine dust applied with a self-mixing power duster equipped with a canvas drag which covered the rows for 10 feet or more behind the duster. This result was obtained by one application of 30 pounds of dust at a cost of approximately $2.35 per acre, including the cost of the material and labor.

The outbreak raged for several weeks and during this time the natural enemies of the aphid, both parasites and predators increased rapidly in numbers. It was not, however, until after considerable losses had resulted in the fields that had not been dusted that the outbreak began to subside due to the activities of these natural agencies.

THE EUROPEAN RED MITE

For several years the Department of Entomology has been conducting experimental studies on the European red mite, particularly from the standpoint of an orchard pest. The results of this year's work, conducted at Wooster, Chardon, Chagrin Falls, and Waterville, Ohio, confirm that of previous seasons, namely, that a dormant application of a miscible oil or an oil emulsion in full dormant strength is a specific against the overwintering eggs. It is planned to extend this work over one more season and then to publish the results.

RED SPIDERS

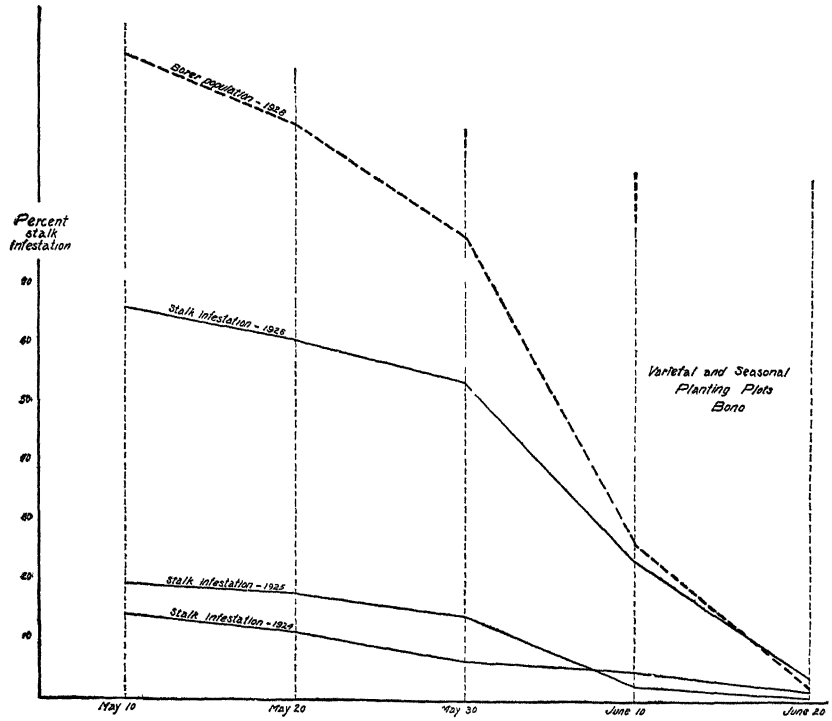
Red spiders on conifers are becoming increasingly troublesome, particularly under city conditions. Thru the cooperation of a northern Ohio nursery free oils were applied as dormant sprays to a considerable number of species of conifers in nursery rows. The work indicates that there is a wide range of tolerance to the effect of dormant applications of oils among the species used and that the Junipers seem to be more susceptible to injury from oil than some of the other species.

CLIMBING CUTWORMS

In the spring of 1926 an unprecedented attack of climbing cutworms was experienced in northern Ohio, particularly in the nursery section. The plants attacked included peach seedlings, the growing buds of budded cherries and plums, grape cuttings, young blackberry, lilac, flowering almonds, pepper bush, Phlox, and other annuals, and many vegetables. In some nurseries the loss was

almost total and involved thousands of plants, particularly those of the annual sorts. Feeding occurred at night, the worms remaining secreted during the day beneath clods and trash and buried in the soft soil near the base of the host.

Spraying and baiting experiments were conducted. The most satisfactory material used was the standard formula of poisoned bran mash scattered along the plant row. This seemed to give almost perfect relief.



Graph showing borer population and percentage of stalk infestation of corn planted at different dates in varietal and seasonal planting plots at Bono in 1926

HORTICULTURE

VENTILATION IN POTATO STORAGE

During the last two years some authorities have strongly recommended mechanical ventilation of potato warehouses, on the basis that renewal of the air retarded both rotting and sprouting. This recommendation has raised the question as to whether the fresh air supplied to the potatoes is itself beneficial or whether it merely aids in maintaining the proper temperature.

Fig. 10.—A cool air storage house recently built at the Ohio Station

It has proved successful in handling this year's fruit crop and also provides facilities for some storage tests

Experiments, at this Station, in which potatoes were stored in air tight containers show that the tubers do not require fresh air as long as the storage temperature is below 40° F. In the fall, ventilation may be an aid in lowering the temperature to this point, particularly in commercial warehouses with large bins. Whether forced ventilation by means of fans is necessary depends, therefore, upon the temperature of the potatoes when they enter storage and upon the amount of normal circulation thru the bins.

The success in holding tubers in sealed cans also shows that ventilation is not necessary during the period that the temperature is below 40°. But in the spring, as the storage temperature goes

above 40° and the tubers begin to sprout, a supply of oxygen is essential. Potatoes sprouting in sealed cans suffocate. At the bottom of deep bins, potatoes are frequently found with an internal blackening and more or less rotting. These are symptoms of suffocation.

The conclusions then are: (1) ventilation may aid in lowering the temperature in the fall to the desired point; (2) ventilation is not necessary during the period that storage temperatures remain below 40°; and (3) ventilation in the spring may aid in keeping the storage cool, and fresh air is essential when the temperature reaches the point where sprouting begins.

TIME OF PLANTING POTATOES

Date-of-planting experiments, extending over six seasons, have led to the general conclusion that the highest yields are from the plantings that mature coincidentally with killing frost. The potato is a cool weather crop. Plantings maturing at about the date of frost take advantage of the favorable cool fall weather and consequently give the highest yields.

The actual date of planting that may be expected to give the highest yields depends upon the date of killing frost and the length of growing period of the crop. Russet Rural, the most popular variety in northern Ohio, requires nearly five months to mature when properly sprayed. Plantings made in the latter half of May and maturing the middle of October have given the highest yields at Wooster.

When potatoes are not sprayed they usually die prematurely from hopperburn. The effect is equivalent to shortening the growing season. Hence, unsprayed crops should be planted later than sprayed crops, in order to secure the best results from the curtailed growing period.

In northern Ohio, planting Russet Rural as early as possible in the spring, usually in April, is an increasing practice. Altho the yields are lower than from sprayed May plantings, the higher price secured from the earlier harvest and the fact that wheat may follow potatoes, may outweigh the reduction in yield. Planting Russet Rurals either early in April or late May is recommended in northern Ohio.

CLOSER SPACING OF POTATO HILLS

The increasing use of fertilizers and the improvement in cultural practices in potato production have frequently resulted in an increase in the proportion of large, rough tubers. Many of these

oversize tubers have hollow hearts. During recent years potato buyers have become more discriminating, and large potatoes are not as salable as those of medium size.

The difficulty is largely overcome by the simple expedient of planting the hills closer in the row. Fortunately the increase in the amount of seed required for close spacing is compensated by higher yields as well as better size tubers. In experimental plots, plantings spaced 9 inches in the row and requiring 20 to 25 bushels of seed per acre, produced about 25 bushels per acre more than plantings spaced 15 inches and requiring 12 to 15 bushels of seed. Each bushel of seed above 12 bushels per acre increased the yield 2 bushels or more. The increased cost was thus covered by the higher yield, and oversize tubers were largely eliminated.

BLOSSOMING DATES OF CHERRIES AND PLUMS

The relative blossoming dates of varieties are of interest from the pollination standpoint. The earliest, latest, and average date of full bloom and the average date of first bloom for the past five years is given in Table 25 for the more common varieties of cherries and plums.

FRUIT SETTING STUDIES WITH THE WINESAP FAMILY OF APPLES

Studies in fruit setting at Wooster in 1925 and 1926 indicated that not all vigorous flowers of Stayman Winesap are capable of setting fruit even tho pollinated by varieties of which the pollen is of high germinability and should be effective. A vigorous flower cluster of Stayman Winesap has one central flower and usually five lateral flowers. The studies showed that a considerably larger percentage of the lateral flowers of this variety are unable to set fruit than of the lateral flowers of such varieties as Baldwin, Jonathan, and Grimes Golden. The full crops of Stayman Winesap that develop under favorable conditions are the result of a small percentage set of a very large number of flowers.

The same inability of lateral flowers to set in large numbers extends to Arkansas Black. Winesap usually sets a larger percentage of lateral flowers than Stayman Winesap. Arkansas (Mammoth Black Twig) has a considerably larger number of both central and lateral flowers that cannot set fruit, regardless of the pollinating varieties, than the Winesap.

This inability of such a large number of flowers to set fruit in these varieties accounts for the greater harmful effects of unfavorable weather conditions during blooming time and frosts during the fruit setting period in decreasing the yields of these varieties than in such varieties as Grimes Golden and Jonathan. The results also emphasize the necessity of keeping trees of these varieties exceptionally vigorous as well as providing for the adequate pollination of the flowers which can set fruit.

TABLE 25.—Blossoming Dates of Cherry and Plum Varieties at Wooster, 1922-1926

Variety	Date of full bloom			First bloom
	Earliest, 1922	Latest, 1926	5-year average	5-year average
Cherries				
Bing	April 12	May 7	April 23	April 27
Brassington	April 17	May 8	April 26	April 29
Dyehouse	April 19	May 9	April 27	April 30
Elton	April 11	May 6	April 24	April 27
English Morella	April 26	May 11	May 1	May 4
Early Richmond	April 18	May 11	April 28	May 1
Governor Wood	April 14	May 7	April 26	April 28
Lambert	April 15	May 8	April 25	April 28
May Duke	April 15	May 7	April 26	April 29
Montmorency	April 19	May 12	April 29	May 2
Napoleon	April 13	May 7	April 23	April 27
Schmidt	April 11	May 8	April 23	April 27
Windsor	April 14	May 6	April 24	April 27
Yellow Spanish	April 15	May 7	April 25	April 29
Plums				
Abundance	April 11	May 6	April 22	April 26
Bradshaw	April 18	May 8	April 23	April 25
Burbank	April 10	May 6	April 22	April 24
Free Goose	April 20	May 9	April 30	May 2
French Damson	April 17	May 8	April 28	April 30
German Prune	April 18	May 9	April 29	May 1
Gueii	April 16	May 8	April 26	April 29
Grand Duke	April 15	May 8	April 26	April 29
Imperial Gage	April 18	May 8	April 26	April 29
Lombard	April 16	May 7	April 26	April 29
Pond	April 18	May 9	April 29	May 1
Reine Claude	April 15	May 8	April 25	April 28
Red June	April 11	May 6	April 22	April 26
Shiro	April 11	May 6	April 22	April 26
Shropshire Damson	April 18	May 8	April 28	May 1
Surprise	April 19	May 8	April 30	May 2
Tragedy	April 15	May 8	April 26	April 29
Washington	April 16	May 8	April 26	April 29
Yellow Egg	April 18	May 11	April 29	May 1

POLLINATION STUDIES WITH THE APPLE

Pollination studies with the apple at Wooster and at Chardon during 1924, '25, and '26 indicate that the following varieties are not sufficiently fruitful when self-pollinated to give satisfactory commercial crops: Baldwin, Delicious, Ensee, Golden Delicious, Grimes Golden, Jonathan, McIntosh, Nero, Northern Spy, Ohio

TABLE 26.—Some Results of Pollination Work, Wooster and Chardon, Ohio, 1926

Pollen variety	Exposure of flowers	Flowers pollinated	Fruit set	Percentage set
Baldwin 359 Wooster				
Baldwin	Bagged	164	0	0.0
	Open	152	4	2.6
Banks	Bagged	58	0	0.0
	Open	34	0	8.8
Delicious	Bagged	74	47	63.5
	Open	80	32	40.0
Ensee	Bagged	48	39	81.2
	Open	52	43	82.7
Grimes Golden	Bagged	14	2	14.3
	Open	86	8	9.3
Jonathan	Bagged	36	24	66.7
	Open	92	51	55.4
Ohio Nonpareil	Bagged	58	0	0.0
	Open	48	0	0.0
Rhode Island Greening	Bagged	70	2	2.9
	Open	178	5	2.8
Normal set—open pollinated, before June drop.		733	258	35.2
Baldwin	Bagged	146	0	0.0
	Open	160	0	0.0
Delicious	Bagged	120	92	76.7
	Open	202	137	67.8
Normal set—open pollinated, after June drop.		532	87	16.3
Rome Beauty—Tree 430				
Gallia Beauty	Bagged	80	1	1.3
	Open	90	3	3.3
Golden Delicious	Bagged	96	51	53.1
	Open	106	23	21.7
Normal set—open pollinated, before June drop.		455	127	27.9
Grimes Golden—Row 410, tree 7				
Baldwin	Bagged	70	1	1.4
	Open	62	2	3.2
Delicious	Bagged	54	20	37.0
	Open	44	15	34.1
Ensee	Bagged	44	27	61.4
	Open	58	32	55.2
Jonathan	Bagged	10	3	30.0
	Open	10	4	40.0
McIntosh	Bagged	38	15	39.5
	Open	32	7	21.8
Ohio Nonpareil	Bagged	56	0	0.0
Rhode Island Greening	Bagged	56	2	1.8
	Open	52	2	3.8
Normal set—open pollinated, before June drop		648	256	39.5

Nonpareil, Rhode Island Greening, Rome Beauty, Stayman Winesap, and Wealthy.

The following varieties were effective pollinizers of all varieties, other than themselves, upon which they were used: Delicious, Ensee, Golden Delicious, Grimes Golden, Jonathan, McIntosh, Northern Spy, Oldenburg, Rome Beauty, San Jacinto, Wealthy, and Yellow Transparent. The following varieties were ineffective pollinizers of all varieties upon which they were used: Baldwin, Banks (Red Gravenstein), Nero, Ohio Nonpareil, Rhode Island Greening, and Stayman Winesap. Gallia Beauty for two years has failed to be an effective pollinizer of Rome Beauty. It has been very effective on Stayman Winesap.

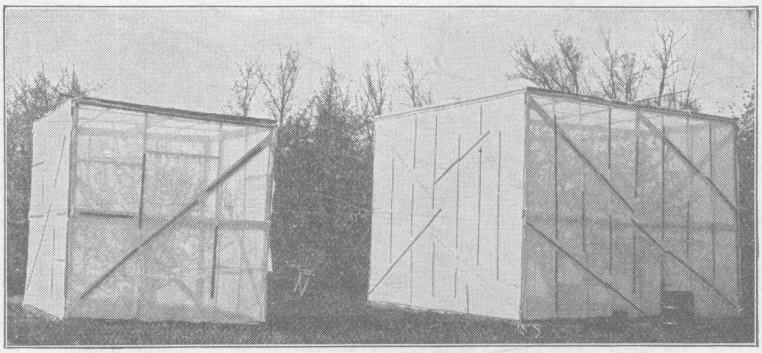


Fig. 11.—Trees enclosed under frames with bees in pollination experiments

Right—Baldwin tree self-pollinated by enclosed bees.
Left —Golden Delicious tree with containers of Baldwin bloom to determine effectiveness of Baldwin as a pollinizer.

ELIMINATING VARIETY MIXTURES IN NURSERY STOCK

Study of trees in the nursery row shows that mixtures may be eliminated and varieties distinguished by means of leaf and other growth characters. Ability to identify varieties is gained by close observation and much association with them. However, certain characteristics have been noted which may be definitely used in eliminating mixtures.

In the peach, for instance, the color, size, thickness, texture, and waves of the leaves are often of value in detecting mixtures. White fleshed varieties may readily be distinguished from yellow fleshed varieties by the degrees of yellow pigmentation in the leaves. More yellow pigment is apparent in the leaves of yellow fleshed than of white fleshed varieties. Furthermore, at least

three types of foliar glands have been observed in peach varieties. These, also may serve a very useful purpose in the elimination of mixtures. Usually the glands are small and round, as in Champion, or larger and kidney shaped as in Elberta. Within the class with kidney-shaped glands some varieties have larger or more numerous glands than others. Again some varieties have very crinkled leaves (Heath Cling), whereas others have not (South Haven). Certain varieties grow much more upright in the nursery than others. The comparative time of leaf fall is also of importance in distinguishing varieties. Some become defoliated very early (Greensboro), early (Elberta), medium (Champion), late (Early Crawford), or very late (Salwey).

STRAWBERRY FERTILIZATION

When strawberries were grown in a rotation in which soybeans are planted after the second crop of berries is harvested, and in which one year of the cycle is devoted to potatoes, the addition of acid phosphate (320 pounds) to barnyard manure (8 tons) gave a higher yield than either acid phosphate or barnyard manure alone. The combined or single use of barnyard manure and acid phosphate gave higher yields than nitrate of soda, sulfate of ammonia, muriate of potash, or lime.

Applications of nitrate of soda or sulfate of ammonia made just before the plants were set in the spring did not appreciably increase the yield of berries. Several applications of nitrogenous fertilizers thruout the season seem more desirable than one in the spring. The use of muriate of potash (50 pounds) either alone or combined with nitrate of soda or acid phosphate gave poor return. Lime proved of little, if any, direct benefit to the yield of strawberries. The unfertilized plots, following soybeans and potatoes, gave fairly high yields the past season.

THE EFFECT OF FERTILIZERS ON THE EARLINESS OF CABBAGE

Nitrogen was found to be the most valuable single element in a series of fertilizer plots at Marietta, in hastening the maturity of cabbage. This element in combination with phosphorus, potash, or limestone was also of great value in accelerating the growth of the young plants. Nitrogen in the form of nitrate of soda, was of more value when applied before planting than when applied in two separate applications, one-half before and one-half three weeks after plants were set. Sulfate of ammonia as a nitrogen carrier was inferior to nitrate of soda.

It was only after the element nitrogen was supplied that phosphorus became beneficial. Potash proved to be of little or no value in hastening maturity. Ground limestone when applied alone showed a moderately beneficial effect but gave no additional increase when supplementing nitrogen, phosphorus, and potash. In all cases in which a complete (4-10-4) fertilizer was used there were good increases in the weight of early cabbage over the untreated plots.

Manure used alone had some value as a stimulant to the young cabbage plants, due probably to its nitrogen content. This value continued when it was combined with acid phosphate and limestone or with limestone alone, but manure in addition to a quickly available form of nitrogen, gave small additional increase. In the manure more than twice as much nitrogen and potash and about half as much phosphoric acid were supplied as in the largest chemical treatment. In spite of this fact the yields were nearly equal in many cases. The production of early cabbage on this soil without the use of manure was practical.

CELERY FERTILIZERS ON MUCK

An experiment to determine the value of fertilizers to muck-grown celery was started at Ravenna in 1925 on land which had not previously been under cultivation. While it is too soon to draw definite conclusions, some of the results seem significant. Lime was of great value to celery on this soil, the limed series of plots showing strikingly higher yields than the unlimed series.

Both potash and phosphoric acid gave increased yields when applied in addition to 1000 pounds of a 2-8-15 fertilizer. Nitrate of soda as a top dressing increased the yields materially. Applying this fertilizer at two separate times was superior to one application. On this land 200 to 300 pounds of nitrate of soda is all that can be profitably applied at one time since larger applications, tho resulting in no injury, produce small increases.

Side dressings of a 2-8-15 fertilizer in addition to a basic application of 1000 pounds of the same fertilizer were effective in increasing celery yields, demonstrating that this crop can profitably utilize large amounts of readily available plant food materials.

An application of chemical fertilizers containing the elements closely approximating those carried in 8 tons of manure, was plainly of more value than that amount of manure. Home-mixed fertilizers in this experiment were better than commercially-mixed fertilizers of the same analysis. Packing-house salt proved neither beneficial nor detrimental to celery.

CULTURAL EXPERIMENTS IN APPLE ORCHARDS

Annual tillage is being compared with the grass-mulch plan of orchard management at five county experiment farms in Ohio. In the tillage system the land is plowed or disked in the spring, cultivated for a short period, and then in early summer sowed to legume cover crops which occupy the ground during the remainder of the growing season and are turned under the following spring. In the grass-mulch method the vegetation of the orchard is cut in June and again in September and allowed to lie where it falls as a gradually accumulating soil covering. The Clermont County Farm is fairly representative of thin, unproductive soil and the Hamilton County Farm of moderately fertile, productive soil. These orchards are thirteen years of age.

At the Clermont farm the two systems have yielded the same. At the Hamilton farm the four-year average gain for the tillage-cover-crop section over the grass-mulch was 9.1 pounds of apples a year per tree or less than one-fifth of a bushel.

The cost of tillage and cultivation including seed and seeding was considerably greater than that of caring for the orchard by the grass-mulch plan, but varied according to the topography and character of soil.

FERTILIZATION EXPERIMENTS IN APPLE ORCHARDS

Experiments in the use of fertilizers are being conducted at seven of the county experiment farms of Ohio. Invariably they have shown nitrogenous plant food to be deficient, especially in the soils of the upland sections of central, eastern, and southern Ohio. This deficiency is usually supplied in promptly available form by nitrate of soda or sulfate of ammonia. There has been no definite indication that one of these substances is superior to the other for orchard fertilization. Sulfate of ammonia contains a larger percentage of nitrogen than nitrate of soda—80 pounds of the former being equal to about 100 pounds of the latter.

Results at the widely scattered farms are quite varied because of the different soils. In the orchards on fertile land, especially where such land was annually tilled, cultivated, and cover-cropped, there was little or no gain from fertilization. On the other hand, on nearly all soils, fertilization of orchards in which the grass-mulch method of culture was practiced, increased fruitfulness. The poorer the soil the greater the increase in yields secured by the use of nitrogenous plant food, as compared with the light yields from unfertilized plots.

Again, on soils low in fertility from lack of organic matter, the use of nitrogenous fertilizers even on tilled, cultivated, and cover-cropped orchard areas produced almost, if not quite, as great increases in fruitfulness of trees as where the orchard on the same kind of land was in grass.

In both the tillage-cover-crop and the grass-mulch sections of the orchard at the Clermont county farm, nitrate of soda and sulfate of ammonia used at the rates, respectively, of 160 and 128 pounds per acre per year, trebled, and in some cases quadrupled, production of apples for the period of four years.

At the Hamilton county farm where the orchard soil is much more fertile, there was but slight gain from fertilization where the tillage-cover-crop system was practiced. But, in the grass-mulch section of the same orchard the four-year average gain was 65 pounds of fruit per tree per year, or 59.6 percent.

ORCHARD SPRAYING EXPERIMENTS, APPLE SCAB AND APPLE BLOTCH

Spraying tests covering a five-year period, 1922-1926, have been completed at the Southeastern Test Farm, Carpenter, Meigs County, in an old Rome Beauty orchard seriously infected by apple scab, and at Layman, Washington County, in a private orchard of old Ben Davis trees so badly infected by apple blotch that no salable fruit had been produced for several years.

Commercial lime-sulfur solution and commercial dry lime-sulfur (powder form), during the 5-year period of spraying tests, gave higher percentages, 91.5 and 92.3 percent, respectively, of fruit wholly free from scab than did standard 3-9-50 bordeaux mixture (83.9 percent). In blotch control these lime-sulfur sprays for the five years gave nearly as high percentages (95.1 and 96.2 percent, respectively,) of sound fruit as did standard bordeaux (99.5 percent). The apples from the plots sprayed with lime-sulfur, both in scab and blotch prevention work, were far superior in color and finish to those from the plots sprayed with standard bordeaux.

The check, or unsprayed plots in the scab and blotch experiments, averaged 10.05 and 11.3 percent, respectively, of fruit free from disease.

Beginning with the second season of these spraying tests, bordeaux mixture of variously modified strengths was used. In consequence a number of rather surprising facts were revealed. It was clearly demonstrated that by careful and thoro spraying—which is of utmost importance no matter what spray is being used—the

amount of copper-sulfate in bordeaux mixture may be reduced to one-third or one-fourth the weight generally recommended, without materially affecting its efficiency as a fungicide in prevention of apple scab and apple blotch. A 1-5-50 bordeaux mixture used at Carpenter in scab-prevention experiments, actually gave a higher 4-year average (90.5 percent) than did standard or 3-9-50 bordeaux (83.9 percent), while the fruit produced on plots treated with the modified bordeaux was of better color and finish than where the standard formula was used. In the blotch-control tests, also, results with the modified bordeaux sprays were surprisingly uniform. Bordeaux mixtures ranging in strength from 3-9-50 down to ¾-2¼-50 were used thru the entire 5-year period. While, as stated above, the 3-9-50 bordeaux gave an almost perfect score of 99.5 percent of apples free from blotch, the ¾-2¼-50 formula gave 98.6 percent of fruit entirely free from the disease. Other formulas of bordeaux of intermediate strength, such as 2-6-50 and 1-3-50, also gave almost perfect control of blotch (99.2 percent) for the period.

Moreover, it was discovered that the complete elimination of copper-sulfate from the 3-9-50, or standard bordeaux formula, by no means resulted, as formerly would have been expected, in total failure of the remaining 9-50 lime and water solution in scab and blotch prevention; for this solution gave a four-year average of 60.5 percent of apples wholly free from scab, and 85.5 percent free from blotch.

It is being demonstrated repeatedly that where really thoro work in applying the sprays is done, providing there are no neglected trees or orchards nearby in the direction of prevailing winds, that the beneficial results of such spraying are, in a measure, cumulative. Therefore, orchards safely isolated from those that are neglected and diseased may be treated with spray mixtures of considerably modified strength. This is especially true of those applications that follow the period of bloom. However, orchards that are badly infested with fungous diseases are a standing menace to adjacent well-cared-for orchards, no matter how thoroly the well-cared-for orchards are sprayed for prevention of disease.

Sulfocide, a very concentrated compound, was used in the proportion of 1 gallon to 200 gallons of water, in the past two seasons in spraying for prevention of apple scab and apple blotch. This spray gave an average of 91.5 percent of scab-free and 96.8 percent of blotch-free fruit. According to explicit instructions from the manufacturer, the sulfocide was used in connection with casein or

"Kayso" and arsenate of lead; but there was some burning of foliage and injury to the calyx lobes of the fruit, the latter injury in some cases extending into the tissue of the apple immediately surrounding the calyx.

Colloidal sulfur used for the past three years in these spraying tests gave 86.2 percent of fruit free from scab and 86.8 percent free from blotch.

DAIRY

LEGUMES FOR MILK PRODUCTION

In a study of the legume hays for milk production two Holstein cows were fed alfalfa hay and ground corn only. One cow, started on this ration five months after calving, eight months after starting dropped a 105-pound calf, and in the next five months averaged 1264 pounds of milk per month. In the thirteen months she produced 11,040 pounds of milk and 382 pounds of fat. The other cow after being on the ration of alfalfa hay and ground corn for four months freshened, and produced in twelve months 11,276 pounds of milk and 351 pounds of fat, and a few days later dropped a 90-pound calf. These good records indicate the value of alfalfa hay for milk production.

A FLY SPRAY FOR COWS

A fly spray consisting of a saturated solution of oil of tar and insect powder (Pyrethrum) in kerosene with a cup of cresol compound in each gallon was used. This mixture was filtered thru a cloth and applied with a hand compressed-air sprayer. The spray was applied lightly (as a mist) to prevent injury.

The herd of 40 cows was divided into two groups. One group was sprayed daily after milking in the morning, the other group was not sprayed. The groups were reversed at weekly intervals during the summer. The flies on the individuals were estimated in the afternoon when the cows were brought in from pasture. The spray proved quite effective in repelling the flies. The counts showed about 70 percent fewer flies on the sprayed cows. Many of the flies were killed when the spray was applied.

The milk production showed little or no relation to the number of flies on the cows. The very sharp decrease in milk production in July and August commonly attributed to "the flies are bad", is more probably due to the shortage of suitable feed during this period.

A REMARKABLE COW

Old Grace Daw 2d, a Holstein cow, born in 1907 and died in 1923, proved to be a great producer and breeder. She dropped eleven calves, of which five were females. From this cow and her female progeny more than a hundred calves have been born in the Station herd. Many of the males have gone out as herd sires; fourteen females were sold before they dropped their second calf, and others were sold later.

In her eleven consecutive 365-day lactation periods, this cow averaged 12,133 pounds of milk and 419.6 pounds of butterfat. Her total production was 133,464 pounds of milk and 4,616 pounds of butterfat. She and her five daughters produced to November 1, 1926, 555,963 pounds of milk and 19,440 pounds of fat. Two daughters are still producing. The average of 58 records of her progeny is 11,767 pounds of milk and 428 pounds of fat. Many times the cows have been on experiments that have kept down their production. Only two of her daughters were by the same sire, yet each of the five was a good producer, and her progeny to the 4th generation have been good producers.

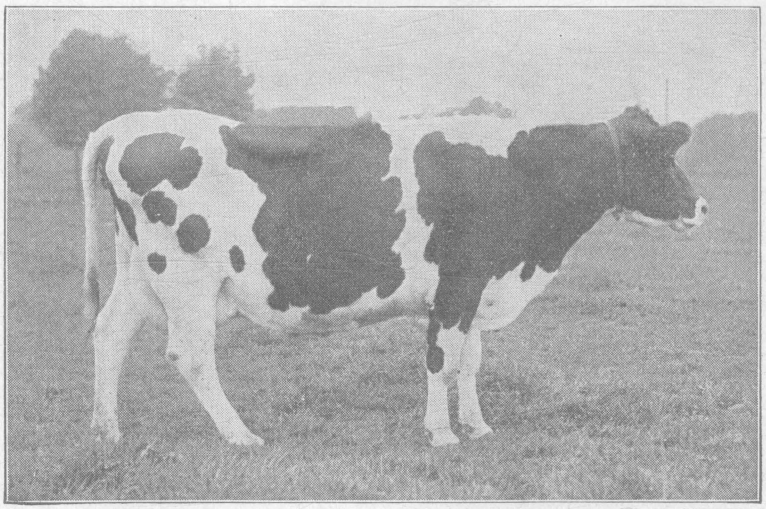


Fig. 12.—Grace Daw 2d

In 11 years Grace Daw 2d produced 133,464 pounds of milk and 4,616 pounds of butterfat. From this cow and her female progeny more than a hundred calves have been born in the Station herd.

This cow, bred to the best sire the Station has owned, produced two daughters each of which exceeded 118,000 pounds of milk and 4,000 pounds of fat; bred to his successor, whose daughters were all discarded but two, she produced a daughter that exceeded 10,000 pounds of milk as a two-year-old. Bred next to a sire that did not improve the herd, she produced a daughter that has averaged 9,700 pounds of milk and 370 pounds of fat each 365 days and has been an excellent breeder.

The breeding of such cows and their female progeny to tried sires is the most certain way to get good producers. More severe culling of cows is seriously needed, especially in purebred herds.

PROTEIN REQUIREMENT OF DAIRY COWS

A study of the protein requirement of dairy cows is being continued with two groups of three cows each. One group receives continuously a ration having a nutritive ratio of 1:2; the other group, 1:13. These rations are about as high and as low, respectively, in protein content as it is possible to secure, if the materials are limited to those commonly fed to dairy cattle, and the ration kept approximately normal in other respects. The rations now being fed are as follows:

Extremely High Protein Ration		Extremely Low Protein Ration	
Alfalfa	16 lb.	Timothy hay	6 lb.
Corn silage	12 lb.	Corn stover	6 lb.
Linseed oilmeal	2 lb.	Corn silage	30 lb.
Cottonseed meal	2 lb.	Corn	6 lb.
Gluten meal	2 lb.	Oats	2 lb.
Soybean oilmeal	2 lb.	Bran	1 lb.
Peanut oilmeal	2 lb.	Hominy feed	4 lb.
Wheat bran	2 lb.	Molasses*	4 lb.
Blood meal	2 lb.	Bone meal	2 oz.

Two cows recently completed a year on the high protein ration, with records of 8,781 and 10,251 pounds, respectively. No noticeable abnormality developed, such as is sometimes attributed to this type of ration, and there was no marked difference in condition between the two groups of cows.

One previous record, 9,355 pounds on a 1:2 ration, is also available. Abnormalities developed in this cow, tho we are unable to state definitely that these were due to the ration.

None of the cows has yet completed a full year's work on the 1:13 ration. The three previously published records of 11,570, 9,709, and 11,761 pounds milk on a ration having a nutritive ratio of 1:11, considered in connection with the three records just given for the 1:2 ration, together with the apparently normal condition of the cows after more than a full year's feeding on each type of ration, would apparently justify a tentative conclusion that a very wide range in protein content of the ration is tolerated without serious ill effect on the cow and without marked influence on production.

Neither the extremely high nor extremely low protein ration is recommended for general use. There would be no advantage in going out of the way, as was done in this experiment, to get a ration that is unusually high or unusually low in protein but at the same time reasonably satisfactory in other respects.

*Molasses, diluted and mixed with roughage.

A liberal ration of medium (inclining toward the low) protein content made up largely of legume hay, corn silage, corn, oats, and wheat bran, with the addition of perhaps 15 percent of one or more of the high protein by-product feeds to the grain mixture is probably the most practical ration for most Ohio farm conditions at the present time.

We believe that many of the differences in production and condition of animals fed different rations which have been commonly attributed to differences in the protein content of the ration may, in reality, be due largely to other causes, such as amount, quality, palatability, or variety in the ration.

ANIMAL INDUSTRY

FEEDING WESTERN STEER CALVES IN DRY LOT AND ON GRASS

The increasing demand for lighter cattle at central markets has been reflected in the feed-lot experiments of the Station, where during recent years calves only have been fed. Several years' work has shown that roughages, such as silage and hay, should not be depended upon too much as mainstays in rations for fattening calves, but that liberal amounts of corn, or other grain, and protein concentrates should be fed. During the past winter's experiment, the ration which had in the past yielded the largest profit, again proved the best of the different ones tried out. This ration consisted of a full feed of corn, two pounds oilmeal, and what alfalfa hay and corn silage the calves cared for in addition. The other rations had less corn, or no corn in addition to that contained in silage.

All groups of calves, regardless of how much corn they had received in their winter dry-lot rations, were turned on pasture in June. Results show that the more corn they had received previously, the more weight they lost during the first weeks on pasture, and the slower they gained in weight thereafter, in spite of the fact that all steers on pasture received a full feed of corn and a limited amount of oilmeal. It, therefore, did not pay to turn these corn-fed steers on grass. They were nearly finished for the market and should have been shipped directly out of the feed lot.

THE EFFECT OF COMPANY AT THE FEED TROUGH

Twenty Aberdeen-Angus calves and yearlings during a 203-day feeding test showed that company at the feed trough so stimulated the appetites, that calves fed as a group consumed more feed than when fed individually, in stanchions. As might be expected, the animals fed as a group made larger gains and cheaper gains.

SOYBEANS FOR PIGS OF DIFFERENT AGES

Swine feeding experiments have shown a wide variation in the feeding value of soybeans. The difference in the age of the pigs used, as well as whether they had received forage, offered possible explanations of the variant results. An experiment was conducted to determine the worth of soybeans, as compared with tankage, for weanling pigs and for 130-pound shotes, both in the case of pasture

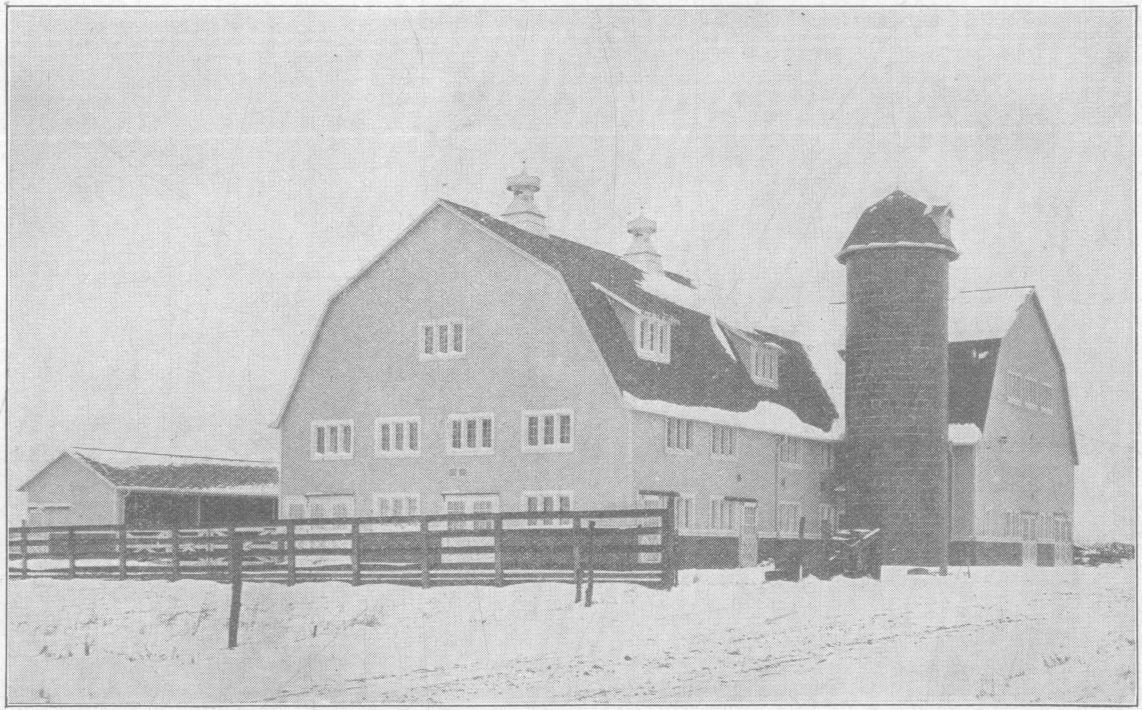


Fig. 13.—The new Beef Cattle Barn at the Ohio Experiment Station

Here experiments are conducted in raising baby beef, wintering beef breeding cows, feeding minerals to beef cattle, and in controlling parasites of sheep.

and of dry lot feeding. With ground corn figured at 75.6 cents a bushel, tankage at $70.00 a ton, and the mineral mixture used at $43.50 a ton, ground soybeans showed a value of $1.25 a bushel for the 130-pound shotes on pasture, $1.08 a bushel for the weanling pigs on pasture, and $1.06 a bushel for the 130-pound shotes not receiving forage. These figures are based on the differences in the feed required per unit of gain alone, and do not take into account the more rapid gains of the tankage-fed pigs. The 130-pound shotes getting soybeans and those getting tankage in connection with pasture gained 1.71 and 1.73 pounds daily a head. Of the pigs on pasture, which were started at a weight of 50 pounds, those getting soybeans gained .92 pound daily and those getting tankage 1.20 pounds daily. The shotes in dry lot receiving soybeans and tankage as supplements made average gains of 1.42 and 1.72 pounds, respectively.

INCREASING THE EFFECTIVENESS OF CORN AND TANKAGE FOR PIGS

Limestone.—In the fourth experiment of a series dealing with the problem of increasing the effectiveness of a corn and tankage ration for winter feeding, 1½ percent of limestone in the ration failed to improve it. Calcium carbonate was used in one of the four trials. A summary of the three, in which limestone was used, shows the addition of limestone to have increased the rate of gain 17.4 percent, and to have lowered the feed cost 12 cents for each 100 pounds of gain. A ration of corn and tankage is thus apparently slightly deficient in calcium for optimum growth.

Skimmilk.—The possibility of improving the quality of the proteins of a corn and tankage ration was suggested by the favorable results again secured by replacing a part of the tankage with a little skimmilk in a ration of corn, tankage, salt, and limestone. Much larger returns were secured for skimmilk when it was used in this manner than when it was fed as the only supplement.

Cod-liver oil added to yellow corn, tankage, salt, and limestone at the rate of .5 pound in each 100 pounds of feed produced more rapid growth, as well as a larger amount of growth from a given quantity of feed. Cod-liver oil that had been treated to destroy its vitamin-A content gave results similar to those from the untreated product. Pigs on yellow corn and tankage seldom show symptoms of rickets, nevertheless it seems probable that these feeds are too low in the anti-rachitic property for optimum development, altho not appreciably deficient in vitamin-A.

Alfalfa meal is regarded as a more practical feed than cod-liver oil for swine. The mixture of tankage 2 parts, linseed oilmeal 1 part, and alfalfa meal 1 part, again made an excellent showing. In this trial it gave cheaper and more rapid gains than a supplement of tankage only, or one of tankage and limestone. Limestone with tankage, linseed meal, and alfalfa meal did not reduce the cost but did still further increase the rate of gain. Linseed meal and limestone made a less effective supplement than the same feeds with alfalfa meal included. Bright, green, third-cutting alfalfa hay was tried as a possible substitute for alfalfa meal. It was readily eaten, particularly during the early part of the test, and proved as efficacious as the alfalfa meal, which also was of excellent quality.

Direct sunlight apparently has a beneficial effect upon growing pigs receiving certain rations. In one test two groups of pigs were given corn, tankage, linseed meal, salt, and limestone. One of these groups was confined indoors, the other housed and fed indoors but given access to a small outside pen with a board floor. The pigs having access to sunlight made the more rapid and economical gains. The difference in favor of the pigs having access to the outside pen was not great at first during the cloudy days of winter, but became more marked as spring advanced and there was a greater amount of sunshine.

Fermenting a ration of corn, tankage, salt, and limestone, and one of the same feeds plus linseed and alfalfa meal resulted in a little more rapid growth, and in slightly greater gains from a given amount of feed, but the saving was not sufficient to cover the extra cost when commercial yeast was used. Practically the same results were secured with self-propagated or home-grown yeast, but despite the fact that this method involves practically no expense it is doubtful whether the benefit derived will ordinarily pay for the extra labor required. A ration of yellow corn and tankage is apparently not deficient in anti-neuritic properties.

MINERALS FOR SWINE

Feeding investigations with swine during the year included a test to study the effect of adding various minerals to the simple mixture of salt 1 part, limestone 2 parts, and raw bone meal 2 parts. This mixture and the various additional minerals were fed with a ration of corn and soybean oilmeal which is known to be deficient in minerals.

Glauber's salts, which is a laxative, was fed at the rate of 10 pounds in each 100 pounds of the mixture. The salts did not

increase the rapidity of growth but brought about a slight saving in feed for each 100 pounds of gain produced.

Wood charcoal, to the extent of 15 percent of the mineral mixture, resulted in neither faster nor cheaper gains.

Potassium iodide, in the limited amount of .05 pound to every 100 pounds of minerals, proved to be beneficial. It is used as a preventive of goiter, and under some conditions seems to have a place in mineral mixtures for growing pigs.

Copperas, or iron sulphate, was used as a source of iron, and fed at the rate of 2 pounds in each 100 pounds of minerals. The pigs receiving it made .2 pound more gain daily a head, and consumed 52.5 pounds less feed for each 100 pounds of gain than those on the same ration without the copperas.

CARRIERS OF PHOSPHORUS FOR SWINE

Acid phosphate (16 percent) proved less valuable than raw bone meal as a source of phosphorus in mineral mixtures for swine. The series included two dry-lot trials in which acid phosphate was fed with corn, soybean oilmeal, salt, and limestone, and one in which soybeans were used as the protein supplement in a ration otherwise the same. The two materials were also compared for feeding with corn, soybean oilmeal, salt, and limestone to pigs on rape and sweet clover pasture to determine whether they would have the same relative values for forage as for dry-lot feeding. The results were in accord with those of the dry-lot trials. The acid phosphate made a poorer showing in both the rate and the economy of gains than the raw bone meal.

Spent bone black and raw bone meal, fed in connection with salt and limestone and a ration of corn and soybean oilmeal, were compared as ingredients of mineral mixtures for pigs in a dry lot experiment and for others on rape and sweet clover pasture. The results in each were slightly in favor of the spent bone black. In these and a previous dry-lot trial the pigs receiving spent bone black and those receiving raw bone meal made an average gain of 1.16 and 1.19 pounds daily a head, respectively, and consumed 380 and 381 pounds of feed for each 100 pounds of gain produced. Spent bone black has an advantage over raw bone meal in being cheaper in price. Special steamed bone meal and so-called raw bone meal in a dry-lot test gave practically identical results. Apparently there is very little difference in the worth of various bone products for use in mineral preparations for swine.

FATTENING LAMBS IN THE CORNFIELD

The second experiment in lambing-down standing corn showed that standing corn alone is an inadequate ration for fattening lambs. On the ration of standing corn alone 23 lambs made an average daily gain of .147 lb., and each 100 pounds gain cost $14.74. When the ration of standing corn was fortified by the addition of .21 lb. linseed oil cake; 1 lb. of clover hay; or .14 lb. linseed oil cake and .88 lb. of clover hay daily per lamb, the average daily gain per lamb was increased to .286 lb., .322 lb., and .353 lb., while the cost of each 100 pounds gain was reduced by $4.72, $5.37, and $5.30, respectively.

Dwarf essex rape grown as an intercrop forage in the corn showed considerable merit as a supplementary forage. Its use effected a material saving in the harvested feeds required for each 100 pounds gain, and also increased the returns per acre made by the lambs.

RAM LAMBS AND OTHER LAMBS AS FEEDERS

Many neglected male lambs make their appearance at the principal eastern livestock markets each year. Up until the age of four months little criticism is offered against these uncastrated male lambs, but after this time they are penalized to the extent of $1.50 to $3.00 per 100 pounds. There is no feeder outlet for the thin bucky lambs and with only packer-buyer competition they are sold at a price far below the price secured for an unsexed lamb of similar form and condition.

In order to collect data on the feed lot performance of such thin ram lambs as compared with ewe and wether lambs, a test was conducted, which included in addition a third lot of ram lambs that had been castrated at the start of the feeding period. The data secured show that the ram lambs made the greatest average daily gain with the lowest feed requirement and lowest cost for each 100 pounds gain. These, nevertheless, were the least profitable group of all due to the penalty suffered at the hands of the packer-buyer. The risk involved in castrating 6-month old lambs seems too great to be recommended as a general practice. While none of the lots proved unprofitable to feed, the ewe and wether lambs in this experiment made a return per lamb over feed cost $1.53 greater than the ram lambs and $1.31 greater than the male lambs unsexed at the start of the feeding period.

STOMACH AND NODULAR WORMS IN LAMBS

In 1924 three systems of management, with and without medicinal treatment, were employed in the experiment for the prevention and control of stomach-worm and nodular-worm infestation in lambs. The system which proved to be most effective consisted of keeping the lambs and their infested dams together in the barn until weaning time and after weaning keeping the lambs continuously on clean rape forage. Also, the lambs were treated with the 1.5-percent solution of copper sulphate at weaning time and once each month thereafter until slaughtered for examination. The eight lambs thus handled showed no stomach worms, and only one nodule in one lamb.

In 1925 the entire crop of 71 lambs, the offspring from 59 ewes, were kept under the 1924 system of management plus monthly treatment, after weaning, with copper sulphate solution. Parasitic infestation in the ewe flock was very severe. Six ewes died from stomach-worm and nodular-worm infestation between April 9 and April 22. Close examination of the ewe flock revealed 23 individuals that showed edematous swelling on the lower jaw and lips. The milk produced by many of these ewes was of such negligible quantity that it was necessary to raise 18 lambs by bottle feeding. These 23 ewes were treated with copper-sulfate solution on April 23, in order to save them from death, which seemed certain if this parasitism was allowed to go unchecked. Two of the untreated ewes died from advanced parasitism less than two weeks after this first group was treated. A second treatment seemed advisable and was administered to all of the ewes on May 8. Mortality among the ewes in the flock ceased after the second treatment. The administration of treatment to the ewe flock may have reduced the source of infestation for the lambs materially, but it was not entirely eliminated.

Several of the lambs on this experiment died while very young and upon post-mortem examination were found to be entirely free from stomach worms and nodules. Two lambs died after weaning. Post-mortem examination showed one of them to be entirely free from stomach worms and nodular worms, and the other to have four stomach worms and no nodules.

All of the 34 wether lambs were slaughtered on October 6, and examined for stomach worms and nodules. There were no stomach worms present in any of the lambs and only one lamb showed one small "pin-head" nodule. The method of management plus the

copper-sulfate treatment in this experiment was 100 percent effective in preventing stomach-worm infestation in lambs raised from heavily infested dams. The nodular-worm infestation was negligible, if we may consider the nodular formations on the intestinal wall as indicative.

NATIVE LAMBS VS. WESTERN LAMBS AS FEEDERS

In a feed-lot experiment, black-faced western feeding lambs made a slightly greater average daily gain than thin native mutton × finewool crossbred lambs which were treated for stomach worms. However, the native lambs did not eat quite as much feed each day and did not require as much feed for each 100 pounds gain. Also, the cost of each 100 pounds gain was $0.36 less for the native lambs than for the western lambs. The initial cost of the native lambs was $3.01 per 100 pounds less than the cost of western lambs. With both of the last two factors in their favor the native lambs returned $2.28 per head over feed costs, and the western lambs only $0.84.

GROWTH OF CHICKS AS AFFECTED BY SUNLIGHT

Two experiments were conducted within the year to determine the relative efficiency of sunlight transmitted by window glass and glass substitutes in the growth and well being of chicks. In the first experiment 300 one-week-old White Leghorn chicks were divided into three lots of 100 each and placed in separate colony houses, 8 by 8 feet, provided with gas brooder stoves. Each house was provided with a 3 by 7 foot "sun parlor" on the south side, to which the chicks had access during the day. The top of the first sun parlor was covered with window glass, the second with one-inch mesh poultry netting, and the third with a screen glass substitute.

All three groups received a mash composed of yellow corn 70 parts, wheat middlings 22, meat scraps 5, bone meal 2, and salt 1, with skimmilk to drink.

The chicks in all three groups grew at an apparently normal rate to the fifth week, when approximately 33 percent of those in the "window-glass" group showed signs of failure, attended with a slower gain in weight. By the eighth week all chicks in this group exhibited signs of severe leg weakness, and accordingly were discontinued. The other groups continued to make normal growth to the close of the experiment, or the 10th week, with no evidence of nutritional failure. No apparent difference was noted between the

direct-sunlight and screen-glass groups. The chicks in both pens made good gains, reaching an average weight of approximately 1.5 pounds at 10 weeks.

In the second experiment five lots each of 21 week-old White Leghorn chicks were confined in our standard laboratory pens in the poultry building. All five lots alike were fed the same mash as used in the first trial. Lots 1 and 2 received no sunlight. Lot 3 was exposed daily to one-half hour of direct sunlight, Lot 4 to one-half hour of sunlight transmitted thru a screen glass substitute, and Lot 5 to one-half hour of sunlight thru a fabric glass substitute.

Lots 1 and 2, controls, exhibited signs of leg weakness and failure between the 4th and 5th weeks. Lots 3, 4, and 5 made equally good growth to the close of the experiment, the 12th week. No marked difference in growth and behavior of the chicks or in the ash content of the femurs was observed in the three exposed lots. Apparently, under the conditions of these experiments, enough of the beneficial rays of direct sunlight were transmitted by the two glass substitutes to protect the chicks against leg-weakness.

GRIT REQUIREMENTS OF GROWING CHICKS

In order to determine whether the young chick requires grit to insure good growth and well being, three separate experiments were conducted. In the first trial four groups of 18 day-old White Leghorn chicks were fed the same basal ration composed of yellow corn 56 parts, wheat middlings 23.5, casein 15, calcium carbonate 2, salt 1, and cod-liver oil 2.5, with water to drink. Two groups were fed the mash coarsely ground with and without granite grit and two were fed the mash finely ground with and without the grit. The chicks were continued on this procedure for 12 weeks without apparent difference in growth or behavior.

In the second trial two groups of day-old White Leghorn chicks were successfully raised to twelve weeks of age on two complete milk rations without supplying grit. The pullets and part of the cockerels were then equally divided into two groups and fed a grain and mash ration with and without granite grit for an additional eleven weeks with no perceptible difference between the two groups.

The third trial consisted of two groups of day-old White Leghorn chicks fed the same complete ration with and without grit, but kept on screens of hardware cloth. Both lots were on experiment for twenty-eight weeks without any apparent difference in behavior, growth, or egg production.

CALCIUM REQUIREMENTS OF THE GROWING CHICK

The work on the calcium requirements of growing chicks has been continued to determine the effect of adding excessive amounts of this element. Chicks fed a ration of yellow corn, wheat middlings, meat meal, and salt showed signs of leg weakness between the third and fourth week. The addition of 2 and 4 parts calcium carbonate retarded the onset of leg weakness, with improved growth, from 10 to 25 days, respectively. In a lot receiving an addition of 6 parts calcium carbonate to the basal ration leg weakness appeared approximately 10 days earlier than the lot receiving 4 parts calcium carbonate.

Fig. 14.—Poultry Day, June 18, 1926. Attendance 3,000

When 3 parts of di-sodium phosphate and 4 and 6 parts of calcium carbonate were fed with the basal ration no signs of leg weakness appeared to 12 weeks of age. Growth was also better where the phosphate was added.

These results appear to indicate that an excessive amount of calcium or a wide calcium-phosphorus ratio in presence of a paucity of the antirachitic factor tends to depress growth and bring on the condition of leg weakness. When proper adjustment of the calcium and phosphorus intake is made, small quantities of the antirachitic factor are required to produce normal growth and bone formation.

THE EFFECT OF COD-LIVER OIL AND ULTRA VIOLET LIGHT ON EGG PRODUCTION AND HATCHABILITY

It is a common observation of poultrymen that egg production and hatchability increase whenever the birds are exposed to direct sunlight. Chick feeding tests have shown that the beneficial effects of direct sunlight in preventing leg weakness are due to the ultra violet rays.

Four groups of 10 White Leghorn pullets were used in a test to determine whether the same factors that operate in the prevention and cure of leg weakness exert an influence on egg production and hatchability. The pullets were confined in pens, 5 by 7 feet, located in the poultry building, and fed a mash composed of yellow corn, whole wheat, dried buttermilk, salt, and 4 percent equal parts bone ash and fine oyster shells. Lot 1 received the basal mash only. Lot 2, likewise received the basal mash, but was irradiated 10 minutes daily, except Sundays, at a distance of three feet by a quartz-mercury vapor lamp. Lot 3 received the basal ration fortified with 2 parts cod-liver oil. Lot 4 was fed the basal mash supplemented with 4 additional parts of a mixture of equal amounts of bone ash and fine oyster shells. A male bird was placed in each pen and rotated daily.

TABLE 27.—Egg Production as Affected by Cod-liver Oil and Ultra Violet Light

Lot	Treatment	Jan.	Feb.	Mar.	Apr.	May	June	Total
1	Basal	10.6	6.3	4.9	3.3	1.4	1.2	27.7
2	Irradiated	8.1	8.5	14.8	11.6	11.5	10.5	65.0
3	2 parts cod-liver oil	9.1	10.2	12.9	10.9	9.3	8.7	61.1
4	4 parts additional minerals	8.7	9.5	11.6	8.3	8.6	8.0	54.7

The egg production per bird for the first six months is recorded in Table 27. Irradiating the pullets or feeding cod-liver oil gave a marked increase in egg production. Apparently the antirachitic factor as supplied by either cod-liver oil or ultra violet light was largely responsible for the increase. The feeding of additional minerals (Lot 4) caused approximately a two fold increase in egg production—suggesting that minerals also exert an influence on production which may bear some relation to the antirachitic factor.

The hatchability of the eggs laid by the pullets of the four differently treated lots between January 23 and May 10 were tested. The results are shown in Table 28.

TABLE 28.—Hatchability of the Eggs as Affected by Cod-liver Oil and Ultra Violet Light

Lot	Treatment	Eggs incubated	Infertile	Fertile eggs hatched
No.		*No.*	*Percent*	*Percent*
1	Basal	95	5.26	47.77
2	Irradiated	401	10.47	62.95
3	2 parts cod-liver oil	328	7.62	40.59
4	4 parts additional minerals	275	3.63	57.74

Hatchability, in this experiment did not run parallel with the antirachitic vitamin intake. Altho irradiation caused a marked increase in the hatchability of the eggs, cod-liver oil, of known antirachitic vitamin potency, did not exert a beneficial effect in this respect. Increased mineral intake (Lot 4) tended to improve the hatching quality of the eggs. This may add further evidence to the existence of a possible inter-relationship between minerals, primarily calcium, and the antirachitic factor as affecting egg production and hatchability.

FAT-SOLUBLE VITAMIN CONTENT OF HEN'S EGGS

To determine the possible variation in the fat-soluble-vitamin content of hens' eggs, eggs were gathered from four groups of White Leghorn hens which had been for nine months under the same management and had received the same basal ration supplemented in varying ways. The basal ration was a dry mash of yellow corn, wheat, oats, wheat middlings, bran, and meat scraps with oyster shells ad libitum. No scratch grain was fed. Pen 12 was confined indoors and received the basal mash fortified with 2 parts cod-liver oil. Pen 13 was confined indoors and received the basal ration only. Likewise Pen 15 was kept indoors and fed the basal mash plus chopped alfalfa hay ad libitum. Pen 16 received the same mash but had access to a bluegrass range. The only sunlight available to Pens 12, 13, and 15 was that which filtered thru the closed windows.

The comparative fat-soluble A vitamin content of the eggs from the four different groups was determined by feeding equivalent increasing amounts of egg yolk daily to rats on a vitamin-A deficient diet. The results, in general, showed that yolks of eggs from the pen receiving cod-liver oil and from the pen on blue grass range were approximately five times as potent in fat-soluble A as yolks from the eggs of the basal pen (13). Alfalfa hay in addition to the basal mash tended to increase the vitamin-A content of the yolks.

In the determination of the comparative antirachitic vitamin content, the "line-test" procedure and "protective method" of determining the percentage of ash in the femurs were used. Generally the results reveal a ten-fold increase in the antirachitic vitamin content of the egg yolks from the range pen (16) over those of the indoor basal group. The feeding of cod-liver oil caused a five-fold increase in the antirachitic factor content of the yolks. Alfalfa hay, on the other hand, did not increase the vitamin-D content of the yolks.

EFFECT OF FERTILIZERS ON VITAMIN-B CONTENT OF WHEAT

During the past four years a study has been made of the influence of fertilizers on the vitamin-B content of wheat. The results of the first year's study, as previously reported, indicated that phosphates alone or in a complete fertilizer produced wheat of the highest vitamin-B content. This was indicated by the greatest number of cases of reproduction and rearing of young among rats. Subsequent results are variable indicating that possibly the vitamin-B content of wheat is influenced to some extent by climate and other unknown factors. The calcium, phosphorus, magnesium, and protein content of wheat is increased by liming the soil, but there is no parallelism between this increase and the vitamin-B content of the particular wheat.

Contrary to reports as found in research literature, the vitamin-B content of wheat is low. The tests showed that 60-70 percent of wheat in the diet was necessary to produce maximum growth and well being. With 45 percent of wheat in the diet as the only source of vitamin B there were a few cases of reproduction but only rarely were the young nursed to maturity. The work is being continued to find, if possible, whether vitamin B in grains is associated with any particular factor. Other grains than wheat will be studied.

LEGUME HAY FOR CHICKENS

Green feed or its equivalent is an essential part of the ration for chickens. No ration is complete without it. The adequate provision of green feed during the winter months when it is most needed to maintain the health of the flock and for winter egg production is often the poultry keeper's most difficult feeding problem. Is there a suitable substitute or equivalent for green feed or some other satisfactory solution of this important problem? During the past three years the Station has conducted extensive tests in an

endeavor to answer this question. From the results secured it seems that the use of legume hays offer the best solution of the winter green-feed problem.

In the test during 1923-24, 115 White Leghorn pullets confined indoors the entire year and fed a high quality alfalfa hay cut in one-half inch lengths in addition to the regular ration averaged 162 eggs per bird. The mortality was 8 percent. Furthermore, the birds were in first class condition at the end of the test. The next year the test was repeated with a similar grade of pullets with practically the same results. While there was no control group, receiving the same ration without the alfalfa hay, the good egg production and low mortality under the conditions of these tests was due largely to the use of the hay, as shown by later experiments (Table 29) with control groups.

TABLE 29.—Legume Hay With Basal Vs. Basal Ration Alone and Basal Ration With Bluegrass Range

50 White Leghorn Pullets to Each Lot

Ration	Eggs per bird, November 1 to		Increase of eggs over basal ration	Mortality
	March 1	October 1 (11 months)		
	No.	No.	Percent	Percent
Experiment 1 at Wooster, 1924—1925				
Basal ration* only	29	95		44
Basal ration plus alfalfa hay, chopped	39	125	32	12
Basal ration plus bluegrass range	36	159	67	8
Experiment 2 at Wooster, 1925—1926				
Basal ration† only	27	90		22‡
Basal ration plus alfalfa hay, chopped	31	137	52	18‡
Basal ration plus red clover hay, chopped	34	125	39	32‡
Experiment 3 at Southeastern Test Farm, 1925—1926				
Basal ration† only	19	89		40
Basal ration plus soybean hay, chopped	38	138	55	26
Basal ration plus bluegrass range	37	170	91	10

*Basal ration: ground yellow corn 30, ground wheat 20, ground oats 20, wheat bran 10, winter wheat middlings 10, meat scraps 10, oyster shells in hoppers.

†Basal ration: ground yellow corn 65, ground wheat 20, meat scraps 10, bone meal 4, salt 1, oyster shells in hoppers.

‡Part of the mortality in this experiment was due to an epidemic of chicken pox.

It is evident from these tests that either of the legume hays makes a valuable supplement to the ration.

In every instance, except the abnormal mortality in the clover group as noted, the use of legume hay increased egg production and reduced mortality. So far as winter egg production is concerned the pullets confined indoors and fed the legume hay did as well as those that received no hay but had access to a blue grass range when weather permitted. But the spring mortality of the indoor birds was slightly more.

HATCHABILITY OF EGGS AS AFFECTED BY FEEDING AND MANAGEMENT

As poultry keeping becomes more intensified the problem of hatchability becomes more imporant. The feeding problem as it affects hatchability involves a number of possible supplements that may be added to the ration. Among the more promising supplements are green feed, legume hay, and cod-liver oil. The effect of direct sunlight and the question of management, insofar as it concerns the method of feeding and whether the birds are confined indoors or not, are also important.

A study of these and other factors supposed to affect hatchability has been in progress at the Station during the past two years. Results which may be of interest and practical value at this time are given in Table 30. In this test each group contained 50 White Leghorn pullets and all were confined indoors except the group on bluegrass range.

TABLE 30.—Hatchability of Eggs as Affected by the Ration and Management

Ration	Hatchability			
	Eggs set	Fertile	Chicks hatched‡	Increase over basal ration§
	No.	Percent	Percent	Percent
Experiment 1, 1925				
Basal ration only*	530	94	31	
Basal ration, skimmilk to drink (no water)	685	91	49	58
Basal ration, alfalfa hay, chopped	645	94	42	36
Basal ration, cod-liver oil 2 percent	749	88	33	6
Basal ration, bluegrass range	1007	98	62	100
Experiment 2, 1925				
Basal ration only*	279	93	46	
Basal ration, cod-liver oil 2 percent	361	91	37	—20
Basal ration, bluegrass range	518	88	58	26
Experiment 3, 1926				
Basal ration only†	906	95	36	
Basal ration, alfalfa hay chopped	1354	95	59	64
Basal ration, clover hay chopped	1026	96	55	53
Experiment 4, 1926				
Basal ration only†	325	76	31	
Basal ration, soybean hay	637	82	61	97
Basal ration, cod-liver oil 2 percent	382	90	26	—16
Basal ration, bluegrass range	944	73	60	94

*Basal ration: ground yellow corn 30, ground wheat 20, ground oats 20, wheat bran 10, winter wheat middlings 10, meat scraps 10, oyster shells in hoppers.

†Basal ration: ground yellow corn 65, ground wheat 20, meat scraps 10, bone meal 4, salt 1, oyster shells in hoppers.

‡Percent of fertile eggs. Average of 9 different hatches in experiment 1 and 2 and 13 different hatches in experiments 3 and 4.

§Calculated thus: 49—31=18; 18÷31=58%

The data indicate that the hatchability of eggs may be largely governed by the ration and management of the breeders. Cod-liver oil failed to improve hatchability in anyone of the three tests. This was rather unexpected, especially since it was in every case effective in preventing mortality and increasing egg production. Further tests will be required for conclusive results. These tests, however, give positive evidence that supplementing the ration with a legume hay or an outdoor range of bluegrass is effective in securing the desired hatchability. In the first year's trials the birds not receiving a legume hay but having access to a bluegrass range instead produced eggs somewhat superior in hatchability, altho in the next year's tests the eggs from the legume-hay groups hatched as well as those from the birds on bluegrass range. However, until more information becomes available on this subject, the safer procedure would be not only to feed a legume hay to the breeders during the winter months but also provide a bluegrass range so they can have access to it whenever the weather will permit.

LITTER MATERIALS FOR THE POULTRY HOUSE

Straw is the most commonly used poultry litter, and the farm poultry keeper who has an abundance of clean bright straw is fortunate, but in many localities it is scarce or costs too much for economical use. The all-mash method of feeding offers possibilities for new sources of material.

Peat as a litter material has attracted considerable attention. Both the American and European products were tested but neither proved satisfactory. The American peat was damp and musty upon arrival and later became very dusty. The 100 White Leghorn pullets on a 20 by 20-foot floor space in this test became so seriously afflicted with bronchitis and respiratory troubles that the litter had to be removed after four weeks. Besides the loss of egg production several pullets died owing to the dust and must from the peat. Must or mold in any kind of litter will cause serious trouble.

In another test a high grade peat moss litter, which appeared to be free from must or odor, was used. It was coarse and carried but little dust at first. After a few weeks it became rather dusty. To overcome this condition it was lightly covered with straw. This aided in keeping down the dust for a while as straw naturally attracts moisture. In three months, beginning with January, the peat moss became damp and filthy and it had to be removed at the end of four months. While it was only partially satisfactory for other reasons the question of expense is sufficient to preclude its use.

Agricultural slag makes a floor covering of considerable promise in sections where it is readily available. A test of this material with 115 layers confined indoors on a 20 by 20-foot floor space without renewal for four months proved quite satisfactory. The droppings were raked off the surface and removed every two weeks. Around the water stand about an inch of the slag which became wet and caked was also removed.

The slag proved different from other litter materials in that it did not become dusty even with continued use. This property is due to the fact it is basic or slightly alkaline and has an attraction for moisture. For spring, summer, and fall use agricultural slag proved satisfactory and showed some advantages not possessed by other materials used for this purpose. Whether it will serve to advantage in winter is a question, as it has not yet been tested for winter use.

The slag may be spread six inches or more deep to serve for several months or in smaller amounts and renewed oftener. It is permeated with sulfur and hydrogen sulfide and has a slightly alkaline reaction which should give it considerable disinfecting properties. It may also aid in keeping down body lice since the hens enjoy dusting in it.

Since the slag was tested in connection with all-mash feeding it has not been determined whether it can be used to advantage as a medium for feeding scratch grain.

THE ALL-MASH RATION AND METHOD OF FEEDING CHICKENS

This new method avoids the feeding of scratch grain in the litter, which is always more or less filthy, or on the ground which is often contaminated with disease and parasites. It is a more sanitary feeding practice. Instead of feeding scratch grain, the grain part of the ration is fed in granular form as a part of the dry mash. The mash is kept before the birds at all times in a suitable feeder which keeps it clean and prevents waste. It involves less labor and skill of feeding and avoids practically all the usual changes of feed and methods of feeding chicks and growing pullets.

The development of the all-mash ration and method of feeding which has been in progress at the Station since 1922, was continued during the past year more extensively and with continued success. The method has proved so satisfactory that it has almost entirely replaced the practice of feeding scratch grain in litter to the Station's flocks, except in certain tests where scratch grain is being continued to secure further data as to the relative merits of the two

methods of feeding. During the past year the new method was employed with 5,000 chicks and the corresponding pullets and 1500 layers. These layers were 18 months of age at the completion of their pullet year and had never had any scratch grain, as they were started on the all-mash ration and method when chicks.

Poultry keepers are showing great interest in this new method of feeding chicks and growing pullets and many are using it with success, judging from reports received from all parts of the country. One poultryman near Wooster, for example, used this ration and method in raising 30,000 chicks. The advantages of the method are obvious and it may now be regarded as past the experimental stage as it has proved a dependable practice.

All-mash feeding for egg production while not so far advanced as for chicks and growing pullets also offers promise of becoming a standard practice. Two years' tests involving 2500 layers indicate the successful application of the new method for egg production.

While greater egg production or less mortality of birds may or may not result depending upon the skill of the caretaker in feeding the scratch grain, there are other advantages of feeding all-mash to the layers which will give this method preference with many poultry keepers over the feeding of scratch grain in litter. Details relative to the all-mash ration and method may be secured from the Station by request.

THE IMPROVED SEMI-MONITOR POULTRY HOUSE

Much progress has been made in recent years in the development of improved types of poultry houses. The shed roof with overhanging front is probably the most popular type of house now being built in Ohio.

The semi-monitor type of house was a favorite twelve to fifteen year ago. Many were built in Ohio and a few are still being built. The semi-monitor type is objectionable for four reasons: it is difficult to ventilate properly; it is cold in the winter; hot in the summer; and it is expensive to build.

The Station has found a simple and inexpensive, tho effective, way to improve this type of house. It was the type of roof that caused the trouble, and to "remove the cause" a straw loft was put in as shown in Figure 1, page 122, Bimonthly Bulletin, May-June, 1926. Further details relative to the installation were published in this bulletin.

BACILLARY WHITE DIARRHEA IN HENS

Two groups of eight hens each were under observation for eight months, beginning May 20, 1925. One group was composed of birds giving positive agglutination reactions in serum dilutions of 1:50 or more with S. pullorum, white diarrhea organism, suspensions. The other group gave negative agglutinations.

The object of the observation was to obtain information on (1) the effect of egg production upon the test, (2) the transmission of S. pullorum infection by pen association, (3) the livability of chicks from eggs of such sources, (4) the egg production of the two groups.

Agglutination tests were made at intervals; trap nest records were kept of the individual hens; and hatchability tests were conducted with available eggs. Variation in breed and possible age of the hens must be considered as influencing factors not adequately controlled. The results obtained under the existing conditions permit these tentative conclusions:

(1) The agglutination test for S. pullorum infection in hens, using a serum dilution of 1:50, is not appreciably changed either during or after discontinuance of egg production.

(2) S. pullorum infection, as determined by the agglutination test, can, in some instances, be transmitted to non-reactor hens by their association with reactor hens.

(3) Eggs from non-reactor hens hatch a larger percentage of live chicks than those from reactor hens.

(4) Egg production is larger in non-reactor hens.

The wattle or intradermic test for S. pullorum infection in hens was used to a limited extent, being checked against the agglutination test. The wattle test fluid was prepared from re-washed agar cultures of S. pullorum organisms, the final sedimentation being suspended in 5 percent phenolized saline solution, and concentrated to the density of a No. 7 tube of the McFarland nephalometer. Results of the work conducted indicate that either test selects a similar number of birds that may be classed as infected. Agreement of the intradermic and agglutination tests was fairly close, tho not absolute.

HOME ECONOMICS

THE EFFECT OF THE USE OF SALT IN COOKING VEGETABLES

A study was undertaken to find out the difference, if any, in the palatability, appearance, and texture of vegetables cooked in water to which salt is added previous to, during, or at the end of the cooking process, and to determine at which time it is desirable to add the salt.

Five types of vegetables were used: the green leafy vegetables, represented by spinach and cabbage; the root vegetables, represented by turnips, carrots and beets; the legumes, represented by dried navy beans and fresh peas; the tubers represented by white potatoes; and seed pods, represented by green string beans. The salt used was chemically pure sodium chloride. Parallel tests were made with tap and distilled water in cooking the vegetables.

The equipment for the experiment consisted of white enamel utensils of similar size and shape, analytical balances, adjusted gas burners and other equipment available in food laboratories. Preliminary tests were made to standardize the method of cooking each vegetable, the amounts and proportions to use, and the approximate length of the period required for cooking each vegetable.

The color of the vegetables studied did not seem to be noticeably changed by the addition of salt (chemically pure sodium chloride) in amounts suitable for seasoning. The texture and flavor of the vegetables were best when the salt was added at the beginning of the cooking process, second in desirability when added after partial cooking, and least when added at the end of the cooking period.

Analyses of the total ash of each type of vegetable studied and the total ash and chlorine content of the water in which the vegetables were cooked were made to determine whether different amounts of minerals were extracted from the vegetables when salt was added at various times in the cooking process. There seemed to be little correlation in the percentage loss of ash from various vegetables when chemically pure sodium chloride used for seasoning was added at relatively the same time and at different times in the cooking process.

THE PHOSPHORUS INTAKE OF PRE-SCHOOL CHILDREN

The phosphorus intake of pre-school children as shown by a dietary study made by the individual method was determined by a four-day study made at Ohio State University. A record of the food actually eaten by a group of 55 normal healthy children should serve at least as an indication of what children should have and it should be of service in settling standards.

Twenty-five of the children selected lived in private homes. All the parents of this group were intelligent and their interest in the problem was evidenced by their cooperation in giving the young women who collected the data the opportunity of being in the home during meal times for a period of four days. Thirty of the children studied were residents of an orphanage. The interest of the persons in charge of this institution was also evidenced by the most cordial cooperation. All fifty-five children live in Columbus. They were all examined by the same pediatrician and pronounced normal as to physical condition. None of the children were more than four percent below the commonly accepted standard of weight for height while the majority were well above the standard.

To collect the data, young women trained in the method, went into the homes and into the institution and weighed the food eaten by each child for four consecutive days. Thru the intelligent cooperation of parents and the persons in charge of the orphanage, it was possible to have the children follow their usual habits in regard to the food eaten. They all seemed to regard the presence of the young women as a matter of course. The data obtained were tabulated and classified. The calorie, protein, fat, carbohydrate, calcium, phosphorus, and iron intake of each child for four successive days was determined and averaged. In addition a comparison of the principal sources of calcium, phosphorus, and iron in the diet was made.

Average calorie intake per kilogram of body weight was 91 and 98 calories for boys and girls, respectively. For the children from 4 to 6 it exceeded every standard except that of Lusk's active boy.

The daily protein consumption averaged 44 grams for boys and 41 grams for girls with a per kilogram intake of 2.79 grams and 2.66 grams for boys and girls, respectively. For the entire group 12 percent of the calories were derived from protein. Children that had a high protein intake were in advance in height and weight of the average child of the same age.

The average calcium intake for the entire group was 0.921 gram, with an average of 1.026 grams for the private home group as compared to 0.834 gram for the institution children. The principal source of calcium for all these children was milk. Every child whose diet was studied had some milk, the amounts used by individual children ranging from about one-third of a quart to one quart daily.

The phosphorus intake for the groups averaged 0.9744 gram, with 1.0855 grams for the private home group as compared to 0.8818 gram for the institution children. It would seem from these data that the adult standard of phosphorus of 1.44 grams is unsuited to children but that at least 0.8 gram of phosphorus should be provided in the child's daily diet. For the majority of the children the amount of phosphorus slightly exceeded the amount of calcium in the diet. For only two children was the reverse true. As with calcium, the principal source of phosphorus in the diet was milk. Cereals ranked next in importance, as sources of phosphorus.

The intake of iron for the group averaged 0.006099 gram, with an average of 0.008175 gram for the private home children as compared to 0.004375 gram for the institution group. Cereals and vegetables were the principal sources of iron, with milk and fruits providing lesser amounts. For the private-home children meat and eggs were important sources of iron.

No data are available by which the vitamin content of the diet could be studied quantitatively. From the liberal use of milk and vegetables it would seem that these dietary essentials were adequately provided. For complete report see Bulletin 400.

RURAL ECONOMICS

FEED AND OTHER REQUIREMENTS FOR PORK PRODUCTION

In compiling the results of five years' cost accounts on twenty Greene County, Ohio, farms it was found that feed and pasture formed 74 percent of the total cost of producing pork, when costs were calculated on the whole herd. The average amounts of feed required on these farms by the whole herd to produce 100 pounds of marketable pork, is shown in Table 31. This was the amount of feed required to maintain the breeding herd and to fatten the pigs for market. The amount of pork produced was taken to be the combined weight of the pigs and the increase in weight of the breeding herd. Thus the marketable pork does not contain the weight of the hogs that died, as the cost of producing them was borne by those that survive.

TABLE 31.—Average Cost of Producing 100 Pounds of Marketable Pork, 1920-1924

Item of cost	Amount	Price per unit	Total value
Feed:		*Dols.*	*Dols.*
Corn.....Bushels..	8.2	0.68	5.57
Oats.....Bushels..	.5	.46	.23
Other grains.....Pounds..	5.9	1.87	.11
Tankage.....Pounds..	9.1	3.02	.28
Skimmilk.....Pounds..	20.9	.35	.07
Other protein.....Pounds..	1.8	2.91	.05
Milk feeds.....Pounds..	14.4	2.06	.30
Pasture.....	.....	.....	.60
Total feed and pasture.....	.....	.....	7.21
Man labor.....Hours..	4.1	.28	1.15
Horse work.....Hours..	.7	.16	.11
Veterinary.....	.....	.....	.28
Buildings.....	.....	.....	.16
Equipment.....	.....	.....	.15
Overhead.....	.....	.....	.27
Taxes and insurance.....	.....	.....	.07
Interest.....	.....	.....	.32
Total cost per 100 pounds.....	.....	.....	9.72

Corn formed the major portion of the ration as shown by the table. The average requirement for producing 100 pounds of pork on these farms was 8.2 bushels, at a farm value of 68 cents per bushel. This was the average monthly price of the corn when fed. Corn hogged down or fed unhusked was charged at a lower rate than cribbed corn. With 17 percent of the corn hogged down, and since a large portion of the corn was fed in the fall, the average price was lowered. Oats and small portions of wheat, rye, and soybeans were used as supplementary grains. Tankage was the main

protein feed used. Some oilmeal was fed and a little condensed buttermilk. Mill feeds consisted of bran, middlings, and prepared hog feeds of various kinds. All hogs had the run of mixed clover and timothy pasture during the summer months.

On the average, a little more than 4 hours of man-labor was required for every 100 pounds of pork produced. This was the next largest item in cost after feed. Horse work was only a minor item. Practically all hogs were immuned against cholera, which tended to make the veterinary item comparatively large. Such items as buildings, equipment, overhead, taxes, and insurance were small. Interest on the herd investment averaged 32 cents per 100 pounds of pork. Including all the various items of cost the total was found to be $9.72 per 100 pounds of marketable pork.

DEPRECIATION ON DAIRY COWS

Work in compiling the record of the Medina County cost route has also progressed. The depreciation on dairy cows as determined by the records of this group for the 5 years 1920 to 1924, inclusive, amounted to approximately $10 per head per year. This figure was obtained by adding together the beginning inventory value of cows, cost of cows purchased, and the value of heifers freshened, and by subtracting from this the sum of all receipts from cows sold or slaughtered, cow hides, and value of cows in the closing inventories, and dividing the result by the number of cow-years represented. Decreases or increases in the market value of dairy cows due to changing price levels during this period were disregarded in placing the values on cows in the inventories. Seventy farm-year records are included in Table 32.

TABLE 32.—Method of Calculating Annual Depreciation per Cow, 1920-1924

	Number	Total value	Value per head
		Dollars	*Dollars*
Cows in beginning inventories	840	77,430	92.18
Cows purchased	110	12,361	112.37
Heifers that became cows	112	12,685	113.26
		102,476	
Cows sold for breeding or slaughter	116	13,685	85.00
Cows condemned–T. B.	43	3,467	80.62
Cows slaughtered on farm	17	838	49.29
Cow hides sold		75	
Cows died	17		
Cows in closing inventories	824	76,310	92.61
Total		94,375	
Depreciation on cows		8,101	
Number of cow-years	813.5		
Annual depreciation per cow			9.96

Annual depreciation per cow varied on the different farms from $4.69 to $21.52. The herd with the lowest depreciation was completely replaced in four years by heifers raised on that farm, while the herd which suffered the heaviest depreciation per cow was replaced twice in five years by purchase entirely. This herd had more than a normal death loss and in addition two-thirds of its cows were T. B. condemned during the year 1924.

The table shows that, of the cows on hand at the beginning of the year, 19 percent were sold, 5 percent were condemned because of bovine tuberculosis, 2 percent were butchered on the farm, and 2 percent died, a total replacement of 28 percent per year, had the number of cows in the herds been maintained.

These figures also give an indication of the average milking life of dairy cows. If it is assumed that all the cows in the herds had an average value of $113 upon freshening and that their beef value was $49, this would mean a total depreciation of $64 during the productive life of each cow. Dividing this by the annual depreciation figure gives a milking life of 6.4 years per cow.

HOW LIVESTOCK ARE MARKETED FROM OHIO

The study of livestock marketing commenced in August, 1926, has shown that the livestock produced in Ohio is disposed of in four principal ways. (1) The livestock producer kills some of his livestock for his own family use. (2) Some meat markets (not all) in the rural sections purchase livestock from the farmer, slaughter it and retail the meat to their trade. (3) Many packers buy livestock direct from the farm or thru direct selling agencies. (4) The livestock which are not disposed of in the above channels are sent to one of the terminal markets.

TABLE 33.—Livestock Produced and Marketed from Ohio for the Year 1925

	Hogs		Cattle		Calves		Sheep	
Shipped to:	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*
Cleveland	604,426		61,576		108,614		361,344	
Pittsburgh	423,133		39,616		59,632		167,452	
Cincinnati	296,437	48.1	36,069	37.1	37,859	47.2	59,121	90.0
Buffalo	185,543		13,254		28,833		76,431	
Other markets*	165,727		28,248		11,013		22,911	
Direct to packer†	948,768	27.3	71,505	14.8	131,246	25.2	49,583	6.5
Farm kill	665,608	19.1	80,855	16.8	18,335	3.5	16,533	2.2
Butcher shop kill	191,301	5.5	150,523	31.3	125,897	24.1	10,125	1.3
Total	3,480,945	100	481,648	100	521,429	100	763,500	100

*Includes Chicago, Columbus, Dayton, Detroit, E. St. Louis, Indianapolis, and Toledo.
†Springfield, Fostoria, and Marion receipts are partly included in direct to packer and part in terminal, as they ship both direct to packer and to terminals.

Table 33 shows that the terminal markets receive 48.1 percent of the hogs, 37.1 percent of the cattle, 47.2 percent of the calves, and 90 percent of the sheep from Ohio. More hogs are sold direct to slaughter than any other kind of livestock, closely followed, however, by calves. A rather large percentage of calves are sold direct to the many small slaughterers around the larger cities. The supply of calves is usually good because of the dairy districts surrounding all the larger cities. More sheep are sent to the terminal market than any other kind of livestock, and very small percentages are killed on the farm or slaughtered by local butcher shops. Farmers themselves kill a greater proportion of hogs and cattle, but very few calves. Local butcher shops kill a large percentage of their cattle, a little more than 30 percent, a rather large number of calves, fewer hogs, and very few sheep.

It will be noticed in the table that Cleveland is the principal terminal market to which Ohio livestock move, standing considerably ahead of Pittsburgh and Cincinnati. Beside Cleveland, the other important terminal markets in order of the amount of livestock received are, Pittsburgh, Cincinnati, and Buffalo.

BUDGETARY DISTRIBUTION OF THE COST OF FAMILY LIVING ON OHIO FARMS

During the period April 1, 1924 to April 1, 1925, 26 farm families located in nine Ohio counties kept detailed records of the cost of living, including cash expended and materials furnished by the home farm. The items of rent and transportation, not being satisfactorily reported, are omitted from the following table. The records were kept in an account book designed jointly by the departments of Rural Economics and Home Economics.

The amounts spent per family varied from $495.95 to $3998.10. The average was $1407.02. The percentage of the total furnished by the farm varied from 11.0 to 54.6 with an average of 29.1.

With this group of families it appears that as the size of the budget increased the percentage spent for food and clothing decreased. Other expenses remained approximately constant or increased. The most marked increases appear in Education and Savings.

TABLE 34.—Percentage Distribution of Budget Items of Twenty-Six Ohio Farm Families, 1924-1925

Family	Total amounts	Percent of total										
		Food	Clothing and dress	Operating expenses	House furnishings	Education	Recreation	Health	Organization dues	Church benevolences and gifts	Life insurance, savings and investment	Unclassified
1	$3,998.10	33.0	8.3	8.5	4.9	1.1	7.6	15.2	0.6	3.1	17.2	0.5
2	2,490.32	23.1	8.8	8.1	4.8	34.6	2.4	1.8	0.6	2.9	12.3	0.8
3	2,451.74	44.3	13.7	13.7	4.0	16.6	1.2	1.0	0.2	2.9	0.5	1.9
4	2,207.48	38.8	10.3	19.5	5.1	0.8	0.6	3.8	0.3	8.8	11.2	0.8
5	1,769.85	43.1	17.6	9.0	10.1	4.1	0.4	4.2	0.8	8.1	2.3	0.3
Av.	2,583.50	35.6	11.0	11.4	5.4	10.9	3.2	6.4	0.5	4.7	10.0	0.9
6	1,611.29	55.7	20.4	5.0	3.5	3.4	1.1	0.9	1.5	3.8	3.7	1.0
7	1,570.82	21.5	11.6	10.3	3.0	1.2	0.1	6.5	0.8	11.0	33.3	0.7
8	1,540.48	38.7	12.2	10.6	7.2	3.9	3.4	13.0	1.6	4.3	1.4	3.7
9	1,441.94	31.0	13.1	18.6	6.8	10.7	4.8	2.7	0.7	3.4	6.4	1.8
10	1,409.71	49.7	19.2	11.8	5.3	1.1	0.2	0.7	0.7	11.1	.....	0.2
Av.	1,514.85	39.3	15.3	11.1	5.3	4.0	1.9	4.8	1.1	6.7	9.2	1.5
11	1,401.08	61.2	6.1	10.1	3.3	1.2	4.4	1.1	.....	8.2	.....	4.4
12	1,346.63	45.6	10.1	17.3	1.3	17.9	0.6	0.7	0.5	0.2	5.6	0.3
13	1,345.96	43.7	13.0	8.6	1.9	10.2	7.0	0.7	1.9	9.7	3.2	0.1
14	1,273.16	45.2	5.6	18.8	8.8	1.0	3.5	0.8	0.4	2.7	12.1	1.1
15	1,183.88	48.4	27.5	8.4	6.4	1.7	0.6	1.7	.....	5.3	.....	.....
Av.	1,310.14	49.0	12.1	12.6	4.2	6.5	3.3	1.0	0.6	5.3	4.2	1.2

TABLE 34.—Percentage Distribution of Budget Items of Twenty-Six Ohio Farm Families, 1924-1925—Continued

Family	Total amounts	Percent of total										
		Food	Clothing and dress	Operating expenses	House furnishings	Education	Recreation	Health	Organization dues	Church benevolences and gifts	Life insurance, savings and investment	Unclassified
16	1,152.78	42.3	15.3	6.7	6.5	1.1	2.5	1.6	2.2	2.5	17.7	1.6
17	1,031.93	55.7	24.9	3.9	6.3	1.9	2.2	0.7	0.3	3.1	.....	1.0
18	1,027.98	40.7	25.1	13.0	5.0	1.9	1.2	1.6	0.9	8.5	1.1	1.0
19	1,013.58	47.8	22.1	8.5	2.6	7.2	2.3	1.5	0.3	4.8	.....	2.9
20	918.14	48.0	14.6	9.2	7.3	0.7	2.3	0.9	2.2	8.5	4.7	1.6
Av.	1,028.88	46.7	20.4	8.2	5.5	2.6	2.1	1.3	1.2	5.4	5.0	1.6
21	886.09	62.2	20.0	8.1	3.2	1.4	.....	2.8	.....	2.3	.....	.....
22	816.41	66.1	12.5	8.9	5.1	0.6	0.5	0.6	1.0	2.0	.....	2.7
23	753.22	71.1	7.0	5.4	5.0	0.1	3.8	1.8	0.2	1.3	.....	4.3
24	724.01	50.1	30.6	6.6	0.8	5.6	2.2	0.9	....	0.8	....	2.4
25	719.97	57.9	24.9	6.5	0.6	.....	0.5	0.6	1.7	6.5	....	0.8
26	495.95	46.6	13.9	1.96	4.7	0.5	6.1	0.5	0.9	2 2	3.0	2.0
Av.	732.61	60.0	18.2	8.6	3.2	1.4	1.9	1.3	0.6	2.5	0.3	2.0
Av. of 26	1,407.02	43.3	14.3	10.8	4.9	6.3	2.6	3.8	0.8	5.0	6.9	1.3

RELATION OF TAX VALUE TO SALES VALUE OF FARM LAND

During the year a study was commenced on some phases of the tax problem as it relates to farm land and real estate. Since a considerable percentage of the total tax revenue in the State is raised by the general property tax, and since reappraisal is now in progress in the State, it was thought desirable to initiate a study of the relation of the valuation placed on farm real estate for taxation to its sales value. The project has been well begun. Table 35 gives both the appraised value for taxation and the sales price on groups of farms in each of five counties of the State. The sales price given is the sales price on those farms sold between July 1925 and July 1, 1926. In another column are the tax valuations based on the recent reappraisement. For the five counties from which data were secured it was found that the appraised value was 81.25 percent of the sales value.

TABLE 35.—Tax Expense on Farm Land Determined from the Sale Price and Tax Valuation in Five Ohio Counties, 1925-1926

County	Sales	Average acres per sale	Average tax valuation per acre			Average sales price per acre	Average tax per acre	Percentage which appraised value is of sales value
			Land	Buildings	Total land and buildings			
	No.	*No.*	*Dols.*	*Dols.*	*Dols.*	*Dols.*	*Dols.*	*Pct.*
Adams	54	109.58	21.22	3.84	25.06	29.13	0.513	86.03
Carroll	67	85.82	23.38	6.52	29.90	39.24	0.605	76.23
Henry	84	57.48	82.23	18.20	100.43	142.36	1.83	70.05
Union	94	97.05	54.53	13.43	67.96	76.95	1.175	88.18
Wayne	80	66.19	53.75	21.81	75.56	88.09	1.167	85.77
Total	379							
Average		83.22	47.02	12.76	59.78	75.15	1.058	81.25

DISTRICT AND COUNTY EXPERIMENT FARMS

The three district and nine county experiment farms not only supplement the work at Wooster, but also determine how widely the results of the experiments are applicable over the State. On these farms are a total of 2500 plots in crop experiments, and 90 acres of orchard devoted to variety, fertility, cultural, and spraying tests. In all such work there is a great advantage in having farms controlled by the Station so that the continuity of an experiment can not be interrupted at an inopportune time, as might be done on a privately owned farm.

The three district farms are owned by the State and receive their support from money allotted the Experiment Station by the State legislature. Each county farm is owned by the county in which it is situated and in the past has been financed entirely by its farm sales and by appropriations from the county commissioners. Since the county farms are used in part to obtain information of wider application than the county in which each is located, the last legislature appropriated a small amount to strengthen their rather limited finances, so that their work might be put on a still higher and more useful plane.

That the county and district farms serve a much wider area than the immediate county in which located is evidenced by the fact that information from them enters into the composition of very many of the Bimonthly and Monograph bulletins of the Station.

The diversity of work on the county and district farms is shown by the following list of projects, the figure in each case representing the number of farms on which the project is carried out: soil fertility tests on farm crops, 12; cereal varieties, 12; soybean tests, 11; apple varieties, 8; apple culture, 9; apple fertility, 9; apple spraying, 8; date of seeding wheat, 5; wheat breeding nursery, 2; European corn borer, 2; drainage, 3; potato tests, 3; vegetable fertility, 2; alfalfa test, 6; forestry, 6; clover strains, 2; corn root rot, 2; poultry, 3; pasture tests, 6; tobacco tests, 2; sheep management, 1; and many other projects of more or less local interest.

The fact that many of these projects are of such a nature that they give information of wide interest is an advantage rather than disadvantage to the farmers of the county which owns an experiment farm. It insures close supervision by the Station. It means that a plan is working whereby they, along with other farmers, can get better information than would otherwise be possible. A few facts of general interest from each of the farms follow.

ORCHARD CULTURAL AND FERTILITY TESTS

The **Northeastern Test Farm** at Strongsville, Cuyahoga County, is now used quite extensively for poultry experiments and potato work in addition to the older fertility, cereal, and orchard experiments. The poultry experiment conducted during the year compared the yearly egg production of pullets which started to lay before October 1 with that of pullets starting to lay after that date. Potato experiments consisted of comparisons of certified seed from different sources in Ohio and other states, variety tests, date of planting test, fertility test, and studies in the growing of potatoes for seed. Results from these tests are given on page 66 of this report.

In the Baldwin orchard the yields in 1926 from different fertility treatments were typical of average results secured for the past several years. Yields reported are from 5 trees in each treatment. The fertilizer applied consists of 7½ pounds nitrate of soda and 7½ pounds acid phosphate per tree.

TOTAL YIELD OF 5 BALDWIN TREES UNDER EACH TREATMENT

Cultural method	Fertilized	Unfertilized
In grass	2275 pounds	340 pounds
In grass, mulched	4145 pounds	3830 pounds
Cultivated	4410 pounds	3515 pounds

APPLE VARIETY TESTS

The **Southeastern Test Farm,** Carpenter, Meigs County, is one of nine places in Ohio where apple varieties are tested. For this section of Ohio the Rome Beauty clearly heads the list as the most dependable and profitable variety for commercial purposes. The Red Rome and Ensee are newer varieties of the Rome Beauty type and are distinct improvements in quality of fruit.

Grimes, Jonathan, Stayman, and Flushing Spitzenburg (or Baltimore) are doing well at the Southeastern Test Farm. McIntosh bears heavy crops of beautiful highly colored fruit but the apples abruptly drop from the trees in the fall at the approach of maturity. The McIntosh is distinctly a fall apple in southeastern Ohio, but doubtless could be kept until well into winter by gathering at the proper degree of maturity and placing in cold storage. Its quality is delightful as grown on this farm.

Shiawassee, another apple of the Snow or Fameuse type and therefore related to the McIntosh, bears heavily. The fruit is beautiful and hangs on the tree better than the McIntosh. It is more acid than McIntosh but of an agreeable flavor when fully

mature. Nero, Mammoth Black Twig, Gilbert's Winesap, and Kinnard are also giving good crops. Delicious bore its first crop at the age of 13 years.

Yellow Transparent followed by Charlamoff are most successful in this section as early summer apples, while Maiden Blush and Wealthy succeed admirably for late summer and early fall varieties.

TOBACCO, STERILIZATION AND FERTILITY TESTS

On the **Southwestern Test Farm,** at Germantown, Montgomery County, observations are made on steaming tobacco plant beds. One bed, which had been steam sterilized annually in the past, was this year sterilized on only one-half. The plants showed a remarkable difference from the very start. At least two-thirds of those on the unsterilized end were unfit for setting. The other one-third, which possibly might have been set by a careless grower, were inferior to those on the sterilized end. This demonstration was carried on because it is not unusual to find growers in the vicinity who, to save expense, practice steaming every other year only.

In the fertility tests plots which have been cropped to tobacco continuously for over 20 years show great variation in yield. The most heavily treated plots have held up well in production, very little or no decrease having taken place in the 20 years. However, H. M. Wachter, who is now finishing his twenty-third year of work on this farm, reports a big change in the physical condition of the soil. Water no longer drains away as rapidly after a rain as it did at the beginning of the test especially on the unfertilized and lightly treated plots where small crops have been grown. This is noticeable in cultivation or in preparing the soil for setting plants during a rainy season.

Observations on the various fertility plots during the summer of 1926 indicated that probably the tobacco yields are somewhat reduced by the presence of root rot.

WHEAT BREEDING AND FERTILITY TESTS

The **Mahoning County Experiment Farm** was one selected by the Agronomy Department for carrying on a wheat breeding nursery. This illustrates how the county experiment farms may supplement and further verify the information secured at the Station. This means not only that the Station staff has the advantage of more widely obtained data but also that farmers of the section in

which the farm is located can feel assured that information emanating from the Station is doubly trustworthy because of the double check which the local farm makes possible.

Further illustration of this point is found in the fertility test where a comparison is made of the following analyses: 0-16-0, 0-16-4, 4-16-4. In this test, which is conducted in a four-year rotation of corn, oats, wheat, and clover, the corn receives two-fifths, the oats one-fifth, and the wheat two-fifths of the fertilizer. The land receives no manure but is limed regularly every four years.

TABLE 36.—Fertilizer Comparison on Limed Land, 8-year Average

Plot	Fertilizer 500 lb.	Increased yields per acre				Value increases	Cost of fertilizer	Balance
		Corn	Oats	Wheat	Clover			
		Bu.	*Bu.*	*Bu.*	*Lb.*	*Dols.*	*Dols.*	*Dols.*
2	0—16—0	5.91	5.26	10.21	839	25.29	5.45	19.84
3	0—16—4	7.64	10.92	11.60	881	30.82	7.85	22.97
5	4—16—4	12.63	11.28	13.22	908	45.12	11.40	25.48

The results are comparable to those secured in a similar test at Wooster. In the Wooster test, which is more extensive, reducing the percent of ammonia from 4 to 2 increased the profit, the yields remaining practically as large while the fertilizer cost was reduced.

LIMING INCREASES YIELDS

On the **Belmont County Experiment Farm** the most outstanding lesson taught by the fertility experiment is that this soil must be limed to grow the highest yields, not only of clover but of the grain crops and timothy as well. Plots 5 and 6 receive the same fertilizer treatment, but Plot 5 is unlimed while Plot 6 receives 2 tons of ground limestone per rotation, applied to the corn crop. The differences in the yields of these two plots have averaged 12.23 bushels of corn, 3.97 bushels of wheat, 1697 pounds of clover hay, and 938 pounds of timothy hay, with a total value of $33.29 for the rotation in favor of liming. Two tons of ground limestone should not cost more than $10 applied to the land. The increase in the clover alone has had an average value of $12.74 per crop, or more than enough to cover the cost of liming. In addition to its effect on the yield, the limestone has produced a marked improvement in the quality of the first year hay crop. On all unlimed plots, even on Plot 9 receiving manure and acid phosphate, the first year hay crop contains a large proportion of timothy, other grasses, and weeds; on the limed plots the hay is more nearly pure clover.

COST ACCOUNT OF CULTIVATED AND SOD ORCHARDS

Cost account figures of the orchard on the **Clermont County Experiment Farm** showed a balance on the profit side 12 years after setting the trees. The orchard now has been set 14 years and the last two years further increased the profit balance. One-half of the orchard is kept in sod, the other half is cultivated each year and sown to cover crops. Each section has 160 trees planted on an area of 2.8 acres.

For the first few years soybeans were grown on the cultivated section as a cash crop. The returns were small, however, because of the natural unproductiveness of the soil.

Due to the fertilizer test in this orchard, one-third of the trees get no nitrogenous fertilizer. The trees of this third have given poor production so that practically all receipts have come from the fertilized two-thirds. The cultivated section came into bearing first and has produced somewhat larger yields but the cost has been nearly enough more to offset the larger yield. The grass section is much more pleasant to work in during rainy weather than the cultivated section which is then soft and muddy.

TOTAL COSTS AND RECEIPTS ON CULTIVATED AND SOD ORCHARD

	14 years, 1912 to 1925	
	Sod, 2.8 acres	Cultivated, 2 8 acres
Receipts	$3261.60	$3843.79
Costs*	1708.25	2184.54
Difference	1553.35	1659.25

CORN VARIETY AND DATE-OF-PLANTING TESTS

On the **Hamilton County Experiment Farm** some corn tests are being made which will afford useful information when the European corn borer arrives in southern Ohio. These tests are for the purpose of securing needed information about corn, especially the relation of the time and rate of planting to yield. In the test which was started in 1926 nine varieties were selected which range in date of maturity from Golden Glow, an early variety, to Boone County White, a large late variety. The varieties were planted in triplicate plots on each of six planting dates, the first May 4 and this followed at ten-day intervals until June 24.

The rate-of-planting tests was planned so that the stand ranges from 1 to 6 stalks per hill on duplicate plots. The influence of time of planting upon yield is recognized by farmers so that the best planting date in a community is pretty well observed. But if corn

*Interest on investment and rent of land not included.

borer control necessitates a change of planting date the information regarding varieties will show which best fit into the change in southwestern Ohio. Making this test before the corn borer reaches this section may save several costly years after infestation begins.

MAINTAINING FERTILITY ON RICH SOILS

Madison County lies in one of the most fertile sections of Ohio. However, the fertility experiments on the **Madison County Experiment Farm** show that these soils, altho possessing much natural fertility, easily sink to the level of non-profitable crop yields unless modern fertility measures are used. The following differences in yields were caused entirely by differences in varieties or in soil treatments:

VARIATIONS IN PLOT YIELDS IN 1926

	Corn	Oats	Wheat	Clover	Soybeans
Highest	84 bu.	62 6 bu.	42. 2 bu.	4109 lb.	18 bu.
Lowest	25 bu.	41.5 bu.	8.66 bu.	2156 lb.	12 bu.
Difference	59 bu.	21.1 bu.	33.54 bu.	1953 lb.	6 bu.

Farmers in this section of Ohio who grow two crops of corn in succession should note that on the fertility plots the second-year corn crop has averaged 22 bushels less than the first year crop. This is where the second crop is unfertilized in any way. Apparently the farmers on this soil type should not grow two corn crops in succession without some fertility treatment for the second crop.

Excellent results are being secured in a grain-farming system with a rotation of corn and wheat with sweet clover sown in the wheat for a plow-down crop. Acid phosphate is applied on both the light and dark soils and limestone is needed on the light colored knolls to make sweet clover sure. Under this treatment what was said to be a very poor field when the farm was turned over to the county for experimental purposes is now producing creditable crops.

FERTILIZING THE WHEAT CROP

On the **Miami County Experiment Farm** wheat has given a larger profit from the use of fertilizers than any other crop. In the fertility test the fertilizers have been applied on the corn, oats, and wheat, with the following results:

INCREASE AND VALUE. AVERAGE OF ALL FERTILIZED PLOTS

	Corn	Oats	Wheat	Clover
Average increase	15 bu.	8 bu.	15 bu.	800 lb.
Value of increase	$10.50	$3.20	$18.75	$4.00

In this test the corn and wheat each gets two-fifths of the fertilizer with the other fifth going on the oats. Correlating this test with the work at Wooster indicates that Miami County farmers could well afford to fertilize the wheat crop more heavily than is the present custom. At Wooster putting the fertilizer all on the wheat has produced an 11 percent larger increase in the crop and has been 18 percent more profitable for the rotation than dividing it among the corn, oats, and wheat as in the Miami test. This greater profit came largely from the increased yield of wheat, which is the money crop of the rotation. Heavy fertilization not only increased the yield of wheat but also produced one-half ton more hay per acre following the wheat. Miami County farmers may not find it practical to put all the fertilizer on the wheat but certainly this crop can well receive a very liberal portion of it.

LEGUMES AND DRAINAGE

On the **Paulding County Experiment Farm** the most outstanding lessons have come from the legume and drainage work. The Paulding clay, which is the type of soil on and adjacent to the experiment farm, has been but little affected by the addition of fertilizers in the field trials. However, when this soil was brought to the laboratory and cultivated under conditions where the physical and moisture conditions could be controlled, the addition of fertilizer made a marked response in the plant grown. This suggested that the physical condition of this soil and not the lack of plant food is the limiting factor in crop yields. Legume roots and tile drainage naturally would be expected to improve the physical condition and the Paulding County experiments show that they increase crop yields. Drainage results for an average of the first two years are given in Table 37.

CORN VARIETIES FOR SILAGE

The variety silage-corn test on the **Trumbull County Experiment Farm** offers a guide to dairymen as to what variety to grow in that section of Ohio. The climatic and soil conditions are different

TABLE 37.—2-year Average Yield of Corn and Oats in Tile Drainage Experiment in Bushels per Acre

Depth	29 feet apart		39 feet apart		49 feet apart	
	Corn	Oats	Corn	Oats	Corn	Oats
24 inches	27.4	60.7	26.9	53.8	29.7	52.5
30 inches	40.0	60.0	45.5	63.3	42.9	55.1
36 inches	45.5	59.4	54.4	62.4	51.1	55.7

Undrained yields Corn 29.7 bu. Oats 39.7 bu.

from those in any other part of Ohio. Data given in the following table are based on actual yields as secured in the variety test on the Trumbull farm and on analyses as made of the same varieties grown on the Station farm at Wooster.

TABLE 38.—Medium Season vs. Large Late Varieties of Corn for Silage. 9-year Average Yield per Acre

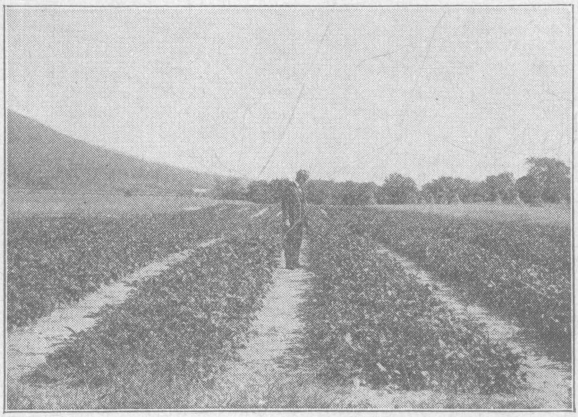
Variety	Yield	Protein	Nitrogen free extract	Fat	Total digestible nutrients
	Tons	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Leaming	8.4	421	3835	124	4535
Reid's Y. D.	8.8	370	3124	85	3685
Blue Ridge	9.2	360	3062	71	3582

These figures indicate that the greatest number of pounds of digestible nutrients are secured in those varieties that make a good tonnage but also reach the glazing stage before being ensiled. Some of the extremely large late varieties while making bulk in the silo may not contain as much total nutrients as a more mature variety.

SHEEP MANURE AS A FERTILIZER

The Washington County Experiment Farm.—Sheep husbandry makes up an important part of the farming enterprise in the hill section of Ohio. Consequently, sheep manure is included in the fertility tests. Applied at the rate of 4 tons per acre on corn, sheep manure has produced an average increase of 14 bushels of corn, 600 pounds soybean hay, 5 bushels wheat, and 850 pounds mixed hay. This makes a value of $6.73 for each ton of sheep manure, if corn is rated at 70 cents per bushel, soybean hay and mixed hay at $15 per ton, and wheat at $1.25 per bushel.

On another plot in the test the manure is divided half, or 2 tons, on the wheat and half on the corn. This increased the profit $4.65 per acre per rotation, over that from the 4 tons all on corn, or added $1.16 to the value of each ton of manure. This has come largely thru increasing the yield of wheat and the grass following. Here, as in tests in other parts of the State, is evidence that it pays to give the wheat crop a good fertility treatment.



Forest seedling trees in the State Forest Nursery

FORESTRY

THE PUBLIC FOREST

At least 80 percent of the forest area of Ohio is contained in the farms, and the forest problem in consequence largely concerns the farmer. He is at once the largest owner of forest property, and the heaviest consumer of wood. He is, or obviously should be, interested in timber growing from the aspect of land use, which involves the utilization of idle and low grade agricultural lands for wood crops, and the removal of these lands from unprofitable competition in the production of agricultural crops.

While most of the forest land of Ohio will always remain in private ownership, there are large forest holdings which the State itself should take over and develop for forestry purposes. In this way it takes the lead in the development and demonstration of good

forest practice. The state forests are fundamental in their relation to the forestry program, and will prove an asset of real importance to Ohio. They are areas made up of inherent timber land, much of which is at least in a semi-wild and neglected condition. The acquisition of such land by Ohio will immediately convert it from unstable to stable ownership, and state ownership for stability is obviously the only remedy at the present time State ownership of land as an example of forest development under stable ownership will be the best example in forestry for the private owner. To bring timber yields from 50 board feet to 300 board feet per acre annually on some 300,000 acres of forest land in southern Ohio and to place this land on a continuous yield basis, would contribute much to timber production and state revenues as well.

The principle of the state forest is economically sound, because it provides for the utilization of wild lands to the fullest extent. The state forest develops methods of forest practice, actually produces timber for commerce, and in so doing yields a revenue. The state forests are now being recognized for their recreational value. They offer splendid opportunities for all manner of outdoor activities, and are highly desirable for recreation in all forms. They may be used for game refuge purposes and, in part, for hunting. They form the protective cover for the watersheds of streams, and provide labor for forest communities.

THE STATE FORESTS

The State Forests comprise the larger bodies of semi-wild lands. The cost of such lands is limited to $10 per acre. Each year since 1920 forests have been acquired and enlarged. The following tracts are now in possession of the State:

Waterloo Forest, Athens County, 421 acres, 2 miles southwest of Mineral, is primarily devoted to experiments in forest planting, and contains a large number of forest plantations of different species and mixtures.

Dean Forest, Lawrence County, 1700 acres, 14 miles north of Ironton, near Steece Post Office, on State Highway No. 75, is largely a second-growth forest, and is part of the Vernon Iron Company holding, which operated during the period when charcoal was used in the reduction of iron ore. The tract contains many forest plantations of pine, planted since 1915.

Shawnee State Forest, Scioto County, 16,876 acres, 12 miles northwest of Portsmouth, on State Highway No. 73, is the largest of the state forests. It is on land formerly largely held by lumber

companies. It is almost entirely covered with second-growth forest, about 20 percent of which is pine. The tract is so well stocked with native forest that very little planting is required. The **Roosevelt Game Preserve** of 8000 acres is located in the center of this Forest.

Fig. 16.—View of Shawnee State Forest from the fire observation tower

Pike Forest, Pike County, 3500 acres, 10 miles east of Waverly, at edge of the village of Morgantown, on State Highway No. 24 from Piketon, is an unorganized unit in process of acquisition. This is in one of the most scenic parts of Ohio, and contains much valuable second growth timber. It contains a considerable area of abandoned farm lands which will be planted to forest.

Scioto Trail Forest, Ross County, 7000 acres, 10 miles southwest of Chillicothe, on State Highway No. 4, is a second growth forest of hardwoods. From the fire observation tower on this forest may be obtained one of the finest scenic views in Ohio. The tower and ranger station are located on an improved road ½ mile off the Scioto Trail Highway.

The aggregate area of the state forests is now 29,497 acres. Some of them will be enlarged in the near future by additional purchases. The average cost of these tracts to date is approximately $6.00 per acre. The tracts are in charge of rangers whose duties are to build roads and trails, plant trees, conduct timber cutting operations, and to protect the land against trespass and forest fires.

THE STATE FOREST PARKS

The state-owned forests of second class are designated by law as forest parks, and include areas of outstanding scenery, virgin forest, or other unusual flora.

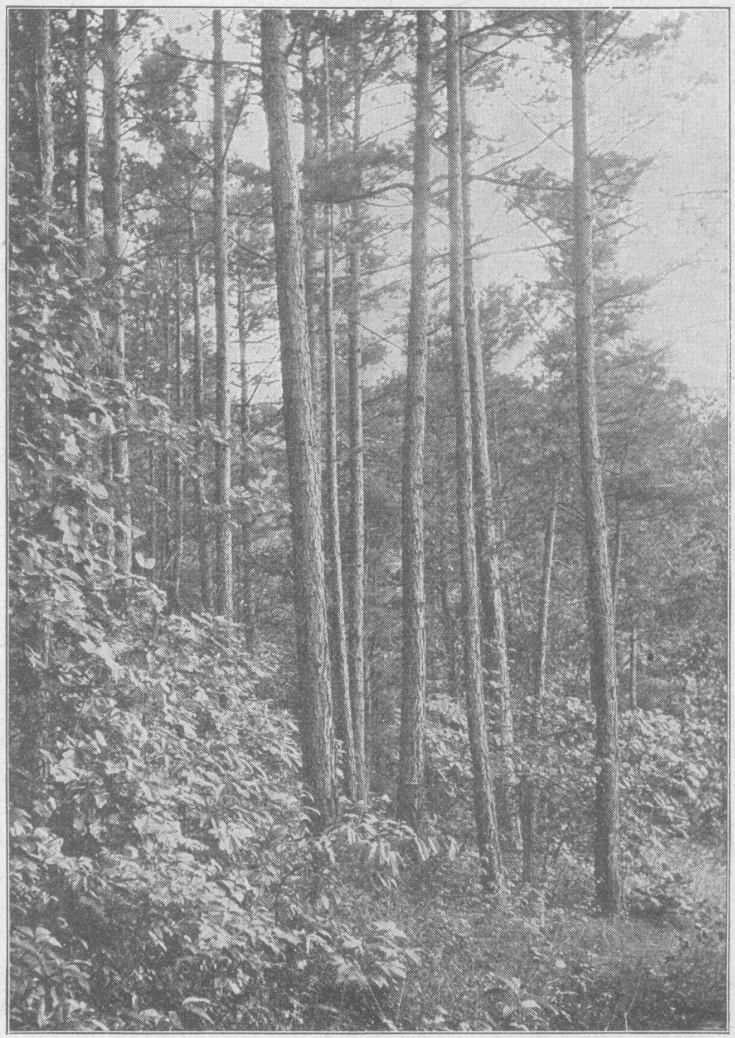


Fig. 17.—Second-growth pine in the Shawnee State Forest

Only places of state wide recognition will be considered for purchase in connection with this class of forests. It is proposed to maintain a high standard for state forest parks in order that the designation will be worthy, and stand for something much out of

the ordinary run of Ohio scenery. If the forest park does not possess some unusual feature there would be no purpose for state ownership. If there are areas worth coming long distances to see, they are also worth acquiring and reserving for public use under regulations and restrictions for protection and perpetuation. This has long been the policy of the Federal Government and many of the states.

The natural features of the forest parks will never be disturbed. Nor will artificial additions of any kind be permitted to detract from the natural attractions. Trails will be constructed to make the tracts accessible, but auto roads will have no place within the limits. Those who would enjoy the forest parks, must walk. Connecting roads between the parks and the arterial highways will be improved to make them accessible by automobile. The following forest parks have been acquired since 1923:

Bryan Park, Greene County, 500 acres, is two miles east of Yellow Springs. This area was a gift to Ohio of the late John Bryan of Cincinnati. It contains 300 acres of woodland, and 200 acres of tillable fields and pasture. The Little Miami River traverses the entire property east and west becoming near the upper end a narrow picturesque gorge cut in the Niagara limestone. On each side of the river numerous springs of heavy water volume issue from the cliffs. The flora is the most varied to be found anywhere in southwestern Ohio, and an unusually large number of tree species occur on the tract.

The fields and pasture are gradually being replanted to forest. It is proposed to use the land for extensive forest planting experiments, and collections of ornamental trees.

Nelson Ledges, Portage County, 40 acres, is 1½ miles northeast of Nelson Center. It can be reached from State Highways 88 and 22. This tract is a ledge of conglomerate rock, which, thru separation and erosion, has been converted into one of the interesting geological formations in Ohio. The crevices, which are accessible for exploration, are in some cases 40 feet deep and but a few feet wide. A number of them contain streams of running water. A fine beech-maple forest covers practically the entire tract. The flora is interesting, particularly the ferns which grow in great profusion.

Hocking Series of Forest Parks.—By far the most extensive, varied, and picturesque of the state forest parks are those in the Hocking County district. There are two groups in this district: those on Pine Creek and those on Queer Creek. The district lies

immediately west of State Road No. 75, connecting Logan and McArthur, and begins about 9 miles south of Logan. The area lies on the extreme eastern edge of the drainage of the Scioto River, and next to the watershed. Just over the hill to the eastward is the territory drained by the Hocking River and Raccoon Creek. The south end of the district is crossed by the three branches of Queer Creek, running in a westerly direction, each in a narrow gorge about 150 to 200 feet deep, the first 100 feet being composed of perpendicular sandstone cliffs. The three outstanding parks here are *Ash Cave* on the south branch, *Cedar Falls* on the center, and *Old Man's Cave* on the north branch, with the rapids above and the falls below. Across the north end of the district Pine Creek runs in a westerly direction. Coming into the Pine valley from the north is a series of narrow valleys and gorges bordered by perpendicular cliffs from 50 to 165 feet high. Commencing at the east side of this series, the names of the narrow valleys are as follows: Big Rocky, *Little Rocky Branch* (state park), *Springer Hollow* (state park), *Crane Hollow*, *Conkle Hollow* (state park), and *Spruce Run* (state park). The road running east and west thru Gibisonville is on the north watershed of these six streams.

Just over the watershed to the north is the *Rock House Park*, one of the finest features in the entire group. This park is only one mile from the Logan-Laurelville road.

The neighboring hills of the district rise about 200 feet above the sandstone into which the gorges are cut. The most of these hills are covered with forests.

The Hocking district is most easily reached by turning south from the Logan-Lancaster road at the west edge of Logan.

In these forest parks are original native trees over a leafy forest floor; shrubs, flowers, and ferns in endless numbers and species; caves, springs, streams, and waterfalls thundering over cliffs into clear pools below, becoming in winter stalactites and stalagmites which meet and form icicles 100 feet long, showing a great variety of coloring under a noonday sun, and this picture framed by nature with the dark green of the hemlocks and the gray and red of the sandstone cliffs. (The work of the hand of man is seen as little as possible. The forest is nowhere "cleaned up" except at the camping sites).

From the bottom of the valleys and from the talus at the base of the cliffs, the stately poplars and hemlocks, whose trunks seem slender, tho in fact very massive, rise to a height of 70 to 90 feet, and from here support their cone-shaped tops extending another 60

Fig. 18.—Rock House Forest Park

"The Rocks" (left). The Hemlock Forest (right)

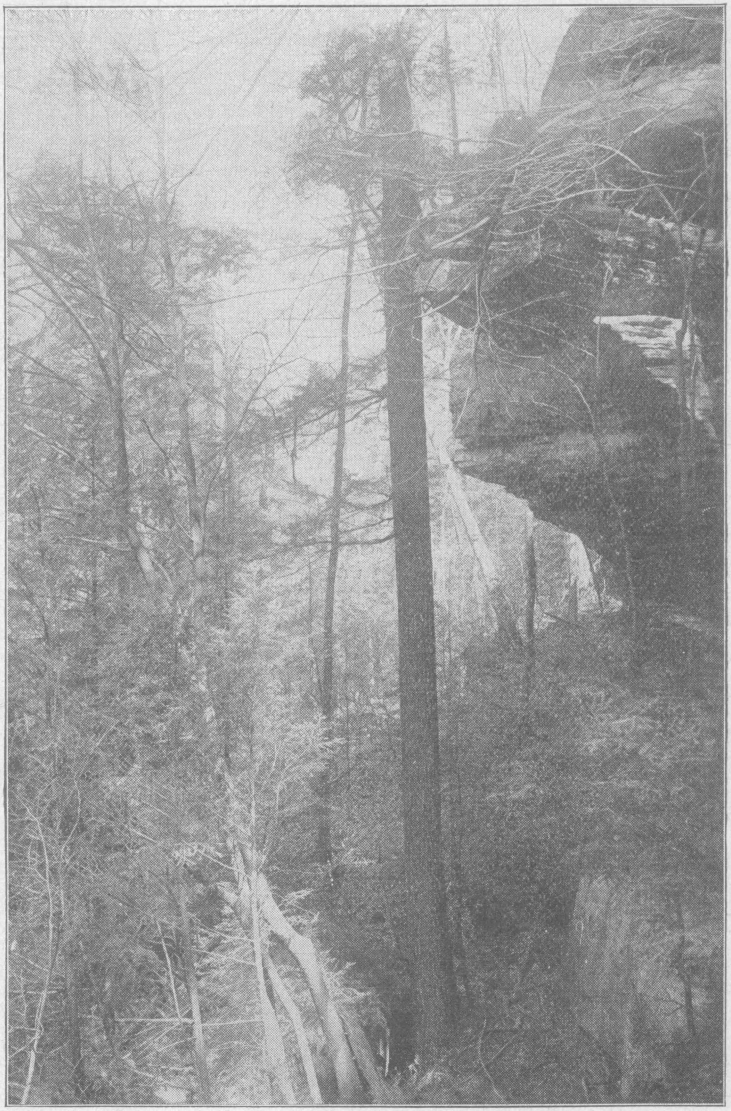


Fig. 19.—Cedar Falls Forest Park, Hocking Series

feet into the air. In contrast with these, the Jersey pine, scarlet oak, and shadbush, with their gnarled, crooked forms adorn the arid knolls at the top of the cliffs. The elms, sycamores, and willows border the winding streams. The sweet birch, rather rare in Ohio, the beech, and the chestnut are found on the steep slopes bordering the bottom of the valleys. Here are also found the mountain laurel, the sourwood, and the Aralia spinosa.

These places are beautiful and interesting to the tourist, the student of nature, or to the scientist at any time of the year; but are especially so at three periods of the year: first, in the springtime when the wild flowers begin to bloom, and the newly formed ferns cover the fertile talus at the foot of the cliffs; again in autumn when the timber on the hills takes on its richest coloring; and in midwinter, when the dark evergreens in the valleys and on the shoulders of the cliffs are covered with snow and long icicles that hang down over the face of the perpendicular sandstone walls that hem in the canyons. Numerous visitors to these valleys see the first and second of these scenes; but to stand and look upon the third, there is a peculiar pleasure in realizing that you are one of only a few permitted to behold its rare beauty.

FOREST PLANTING

Interest in forest planting is increasing among all classes of landowners in Ohio. The notable increase in lands planted by mining and refractory operators is gratifying for these companies are in many instances owners of large tracts of surface suitable only for the growing of forests. The farm owners, however, continue as the group planting the largest number of trees.

The following record of trees distributed from the state forest nurseries, and the number planted by different classes of landowners is for the past year.

TREES DISTRIBUTED FROM FOREST NURSERIES IN FALL 1925 AND SPRING 1926

Private owners	1,153,943
Mining and Refractories	130,600
Cities (city forests)	116,330
Public Institutions	21,735
Boy Scout Organizations (Reservations)	16,475
State Lands (state forests)	90,668
Fish and Game Associations	2,500
Total	1,532,251

Forest nurseries.—The new forest nursery of 55 acres located at Marietta, and authorized by the last General Assembly, was put in operation last spring, and now contains approximately

2,500,000 seedling trees and transplants. This and the nursery at Wooster are the two principal nurseries. Smaller units are maintained at Shawnee State Forest and Rock House Forest Park. The number of trees in the several nursery units now totals approximately 7,480,000.

Nursery trees are distributed for forest planting purposes only, and are not suitable for ornamental uses. Land owners are required to pay the cost of packing and delivery of trees to the transportation company, which is from $1.50 to $2.00 per thousand. The following species of trees were distributed from the nurseries the past year: black walnut, tulip poplar, black locust, white elm, white ash, red oak, white oak, catalpa, sugar maple, white, Scotch, red, and Corsican pine, Norway spruce, bald cypress, and European larch.

The cities of Cleveland, Cincinnati, Akron, Forest, Oberlin, and Springfield have established forest planting areas, either as reservations or for the protection of the potable water supplies. Cincinnati has 700 acres of forest plantations in the municipal forest, the project being started in 1913. The city of Akron contemplates the planting of at least 500 acres of forest for the protection of the potable water supply.

FOREST FIRES

For a great many years, surface fires have been prevalent in the large wooded areas in the southern part of this State. These fires were all too often allowed to burn until they burned themselves out or until it rained. The present poor condition of the timber in large sections of the fire district is due more to the effects of fire than to saw mill operations, tie-cutting, grazing, or any other one cause or all of them put together. It would be impossible to estimate the amount of damage that has really been done by these fires, but there is no question but that it has been very large. For example, one fire alone in 1923 outside the then organized fire district destroyed more than $100,000 worth of tie timber in Lawrence County. Some idea of the amount of damage can also be gained from the figures that will be found in this report. These figures, it should be remembered, are for damage that was done in but a few hours time and is but a small fraction of the damage that would have resulted had not there been an organization to stop the fires.

The forest survey, which was conducted prior to the establishment of the fire warden system, determined that at least 400,000 acres of woods within the ten counties covered by this work had

been burned hard enough to leave unmistakable evidences of the damage. This area includes only those lands that had been burned within ten years of the date of the survey. The area is about one-third of all the wooded area of the ten counties, and no doubt much of it was burned more than once in this ten-year period. It should also be appreciated that these woods cover lands that are too steep and rough to be well adapted to agricultural uses. Their usefulness now and in the future depends upon the quantity and quality of timber that they grow.

While they seldom cause the loss of all of the trees in the stand, surface fires destroy or indefinitely delay the results of the natural reforestation that is represented by the millions of small trees commonly referred to as "brush", and usually scald and cause the deterioration and decay of the greater part of the larger trees that survive the fire. Following a fire the better species, such as white oak, chestnut, and poplar, which are among the kinds suffering greatest loss, are crowded out by inferior species. Such intangible damage as is represented by the injury to the soil and site conditions is extremely difficult to appraise in dollars and cents. It is the logical thing to put an end to these destructive processes and to give the woodlands a chance for normal development.

CAUSES OF FIRES AND FIRE PREVENTION

Forest fires from lightning are extremely rare in Ohio, and the loss from this cause is wholly negligible. Practically all forest fires in this state are caused by human agencies and are therefore preventable. They are due to maliciousness, to carelessness, to lack of judgment, and to lack of proper precautions in connection with necessary or unnecessary operations.

Forest fires from human causes are the result of either necessary or unnecessary operations. It is necessary to run a railroad. It is unnecessary to build a campfire. It is necessary to use coal-burning locomotives on railroads, to run sawmills in the woods, and to burn brush and trash on the farm. Certain other activities or accidents more or less unavoidable are the cause of a few fires which are grouped here. Fires from railroads, from sawmills, from the burning of brush, etc., and from miscellaneous causes taken all together have caused a total loss estimated at nearly $35,000 during the past four years.

This loss might have been prevented. Losses from railroad fires can be prevented by clearing away inflammable material to a safe distance from the track, and by proper inspection and repair of

spark screens and ash-pans of locomotives. Fires from sawmill operations can be prevented by clearing away dead leaves, dry grass, etc., from the vicinity of the mill site. Forest fires resulting from the burning of brush, weeds, grass, and rubbish on the farm can be prevented by giving due regard to the weather and other conditions before starting the fire, and by judicious management of the fire and the use of proper guards and fire breaks. All burning of this kind that is undertaken in dry weather, should be done late in the day after the wind has gone down. Burning in the middle of the day is responsible for the starting of most forest fires from this cause.

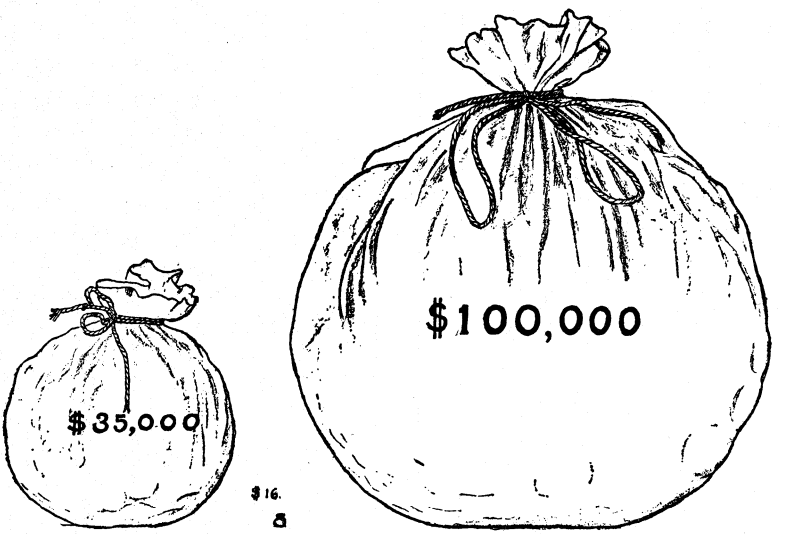


Fig. 20.—Damage caused by forest fires in last four years

Fires arising from unnecessary activities	$100,000
Fires arising from necessary activities	$35,000
Average cost of suppression per fire	$16

Forest fires arising from unnecessary activities caused a loss nearly three times as great as the fires which originated from carelessness incident to necessary activities. Campers, smokers, and incendiaries were responsible for three times as much destruction as railroads, logging, brush burning, and miscellaneous causes combined. The total estimated loss from these unnecessary activities was $100,000 for the four years during which forest fire records have been kept. It is hard to excuse any person for causing a forest fire in any one of these three ways. It is a very small task that can be accomplished in less than five minutes to cover a small camp fire with earth—and there is no justification for building a large

camp fire in the woods. It is no task at all to extinguish a match or cigarette thoroly before throwing it away. It is of course criminal to set the woods on fire intentionally and maliciously. It is practically certain that most fires reported as of unknown cause were due either to camp fires, cigarettes, etc., or to malicious intent. They are therefore included in this group. Areas burned, estimated damage, and cost of extinguishing fires originating in these various ways are given in the following table:

TABLE 39.—Summary of Forest Fires by Causes

Cause	Acres burned	Estimated damage	Cost of extinguish	Total cost and damage, columns 2 and 3
	No.	*Dols.*	*Dols.*	*Dols.*
Lightning	0.3	10.00	6.30	16.30
Railroads	2,351.25	5,729.75	837.22	6,567.07
Logging	985.25	3,525.00	177.56	3,702.56
Brush burning	6,601	16,106.50	2,059.82	18,166.32
Campers	5,418.2	13,811.75	1,066.35	14,878.10
Smokers	444	2,960.50	153.17	3,113.67
Incendiary	12,055.5	27,643.00	1,861.99	29,504.99
Miscellaneous	2,272	5,840.00	516.10	6,356.10
Unknown	22,301.5	49,975.50	2,758.50	52,734.00
Total	5,2429	125,602.00	9,437.01	135,039.11

THE FIRE FIGHTING ORGANIZATION AND ITS IMPROVEMENT

The organization of the forest protective system was begun in the summer of 1922. This organization depends in the main upon the selection of responsible residents who are willing to assume the duties of a fire warden, and their appointment under the fire laws by the State Forester.

It is believed that conditions in the Ohio Forest Fire District for the fiscal year, July 1925 to June 1926, inclusive, showed a good deal of improvement both as to reduction in the number of fires and general efficiency of the fire warden organization. While the reduction in the number of fires was due to some extent to the more favorable weather conditions, there is reason to believe that some of it was due to better fire prevention activities.

The greatest single step toward increased efficiency was taken when in the fall of 1925, four season-long division wardens were appointed. Each of these men was assigned to a definite portion of the fire district. Thru the aid of these four men, each local warden was visited at least once, and some wardens several times during the fire season, forest fire warning signs, and law posters were more

widely used, forest fire tools distributed, and other activities accomplished. In this connection, attention should be called to the fact that the local district and deputy wardens receive no compensation for their responsibilities other than that paid them for actual work performed at forest fires or for the posting of fire notices, etc. A very few of them are employed for a few weeks each spring and fall as forest patrolmen and lookout watchmen.

Occasionally it is found that a local warden has changed or is going to change his work or residence, or thru failing health or otherwise is no longer able to continue his duties as fire warden. The division warden is usually able to locate a new man to take up the work and the organization is kept intact. The division wardens thru their frequent trips are able to bring about much more satisfactory conditions as to the observance of the fire laws. They are required to report at least once a week to the office of the assistant forester at Portsmouth, who is thus kept informed as to conditions and needs in all parts of the fire district

Another factor that has been a great help toward increasing the effectiveness of the fire towers, has been the employment of "smoke chasers" or messengers who leave the State Forests or other point designated as their "base" immediately upon receiving notice from the towerman that there is a fire. They drive their car to the vicinity of the fire, notify the local warden or wardens who have not yet discovered the fire, and bring them tools and assistance. The smoke-chaser is given a commission as "Forest Fire Warden at Large" so as to enable him to summon help anywhere in the territory covered by the tower and to take charge of the fire suppression work himself if necessary. The towerman at the Scioto Trail Tower acted both as towerman and smoke-chaser, leaving the tower whenever a smoke was discovered. If there were good telephone service all over the country districts there would be little need of smoke chasers. However, a large part of the territory covered by the fire towers is either without any telephone service, or such as there is, is too slow and uncertain to be depended upon. Between fires the smoke chasers were employed in improvement work on the Shawnee and Scioto Trail State Forests, respectively.

At the end of June, 1926, there were approximately 277 local district and deputy fire wardens. At the present time (Nov. 10, 1926) there are 329 wardens distributed as follows:

Eastern Adams and western Scioto County (Div. I)	126 wardens
Eastern Scioto and western Lawrence County (Div. II)	58 wardens
Pike County and eastern edge of Highland County (Div. III)	66 wardens
Ross, Hocking and western Vinton County (Div. IV)	56 wardens
Eastern Vinton and western Athens County	23 wardens
Total	329 wardens

That part of the fire district within Adams, Scioto, and Pike Counties is in very fair condition as to the number and location of fire wardens. A good deal more work is called for to complete the organization in Ross, Hocking, Vinton, and Lawrence Counties, and especially in the last two. As soon as this is done the organization should be extended into Jackson and Gallia Counties, which have no fire wardens at the present time.

During the fiscal year from July 1925 to June 1926, the number of wardens was increased about 24 percent, or from 223 to 277. Since June, 1926 it has increased 19 percent, and there are other men who are ready to receive commissions, especially in Ross and Vinton Counties.

THE FIRE OBSERVATION TOWERS

Three 65-foot steel towers used for the detection and location of fires have been erected on the Shawnee, Dean, and Scioto Trail State Forests. An observer is constantly on duty on these towers during periods of drouth when the fire hazard is high. The towers have a visibility of about 12 miles. The cost of the towers erected is $1050 to $1150, depending on location.

While the services of patrolmen in wild and inaccessible districts will be needed for some time to come, the extension of the lookout tower system should gradually take their place. One man on a fire tower can cover several times the area protected by a patrolman who rides the ridges on horseback, and does it better. The towerman has at hand the means for closely locating the distant fire and quick communication with smoke chasers and fire wardens who can insure prompt action. The towermen and smoke chasers probably protect as much territory as the patrolmen, but the services of the many patrolmen cost nearly four times as much. Economy and efficiency call for the extension of the tower system as rapidly as funds permit.

FOREST FIRE WARDENS' REPORTS

The figures in Tables 40, 41, and 42, as well as the information on the map and most other figures herein, were derived from the forest fire reports for the first four years of the forest protection

work. In Table 41, is seen a wide variation between years in the time limits and severity of fire seasons, and it is especially noteworthy that fires occur to some extent during every month in the year. Table 41 presents the real gauge of fire trouble. It is seen that of the year's total acreage burned over, 46 percent was in April, 25 percent in November. March and October followed third and fourth in the order of areas. In amount of damage, April again ranks first with 54 percent of the lost woodland values. The table also shows the costs involved in actual fire fighting only, for wardens and their helpers. Table 42 is arranged by fiscal years instead of by calendar years, and summarizes the data of Table 41.

Fig. 21.—A forest fire (above) as seen thru the towerman's field glass

Depressing desolation (below) caused by the reckless use of fire

Table 43 is a statistical view of the fires of the past year from the standpoint of the relative number and area of fires according to their cause. The main facts in the table are graphically represented in Figure 6 which contrasts the percentages as to cause by number and area.

TABLE 40.—Precipitation Data Taken by Dr. H. A. Schirrman at Portsmouth, Ohio 1922-1926

"Fall" months	1922	1923	1924	1925	Average per month
	In.	*In.*	*In.*	*In.*	*In.*
July	2.86	4.63	2.84	6.01	4.08
August	2.70	3.67	3.53	.85	2.69
September	3.63	2.54	4.81	2.94	3.48
October	2.58	1.33	.18	7.11	2.80
November	.93	3.38	1.94	4.65	2.72
December	4.29	6.95	3.44	.58	3.82
Total for 6 mo.	16.99	22.50	16.74	22.14	19.59
"Spring" months	1923	1924	1925	1926	
January	4.61	5.25	2.57	4.44	4.22
February	4.38	2.44	2.95	2.75	3.25
March	3.80	3.10	3.19	6.17	4.06
April	4.98	2.69	2.72	3.72	3.53
May	2.18	4.22	2.87	2.20	2.87
June	4.26	3.15	2.07	2.83	3.08
Total for 6 mo.	24.71	20.85	16.37	22.11	21.01
Total for year	41.70	43.35	33.11	44.25	40.60

A study of columns 1, 4, 10, and 11 (Table 42) brings out some interesting principles. First, that in the years when there are the most fires, the area per fire is much greater, other things being equal. This is rather to be expected, for when conditions are very dry and fires start more easily, there are both more of them and they spread with greater rapidity. Second, that the cost of suppression per fire is higher in the bad fire seasons, for it costs more to suppress large fires than small ones. Third, that the cost of suppression *per acre* is *smaller* for the large fires than for the small ones, and, unless considered in connection with the size of the fires extinguished, suppression cost per acre spells nothing as to the efficiency of the fire fighters. This principle will be more easily understood if two squares are drawn on a piece of paper, the first one, one inch square, and the second, two inches square. It is only *two* times as far around the second square as it is around the first, but the area of the second square is *four* times as great. Therefore in considering the relative cost of extinction per acre, it must be realized that it takes only half as much labor *per acre* to extinguish

TABLE 41.—Forest Fires in Ohio Fire District. Number of Fires, Acres of Woodland Burned, Estimated Damage, and Cost of Suppression July 1922 to July 1926, by Months

Month	Number of fires							Acres of woodland						
	1922	1923	1924	1925	1926	4-year average	Percent	1922	1923	1924	1925	1926	4-year average	Percent
January	.....	2	5	3	1	3	1.8	.....	20	27½	32	28	27	0.2
February	.....	1	0	7	2	3	1.7	.....	6	.....	96½	5½	27	0.2
March	.....	26	10	53	12	25	17.0	.....	1,770	181	4,366	109¼	1,606	12.2
April	.....	39	41	95	39	53	36.0	.....	8,879½	1,894½	12,606½	901½	6,070	46.2
May	.....	14	6	12	38	18	11.8	.....	563½	292	358	1,098	578	4.4
June	.....	1	0	5	1*	2	1.1	.....	2½	.....	137½*	0*	35	0.3
July	0	1	2	1*	.....	1	0.5	.....	5	7	8	.....	5	.....
August	1	0	2	4	.....	2	1.1	12	.....	9	40¼	.....	15	0.1
September	2	0	0	6	.....	2	1.4	1¼	.....	.....	42	.....	11	0.1
October	14	7	23	1	.....	11	7.6	586¼	380	2,809¼	40	.....	954	7.3
November	32	12	41	4	.....	22	15.0	5,080	151	8,151½	6	.....	3,347	25.4
December	1	2	5	22	.....	7	5.0	12	1	358	1,509¼	.....	470	3.6
Totals	50	105	135	213	93	149	100.0	5,691½	11,778½	13,729¾	19,242¼	2,142¼	13,145	100.0

Month	Damage by fires (estimated), Dollars							Cost of suppression, Dollars						
	1922	1923	1924	1925	1926	4-year average	Percent	1922	1923	1924	1925	1926	4-year average	Percent
January	.....	17.50	94.00	24.00	56.00	$47.88	0.1	.....	26.16	9.00	25.15	13.40	18.43	0.8
February	.....	12.00	.....	198.00	8.00	54.50	0.1	.....	18.50	.....	35.38	18.50	18.10	0.7
March	.....	3,420.50	561 50	10,491.00	179.00	3,663.00	11.7	.....	280.74	114.99	1,072.12	43.55	377.85	15.4
April	.....	23,777.50	5,600.00	36,074.50	2,347.50	16,950.13	54.1	.....	694.47	687.25	1,790.70	418.07	897.62	36.5
May	.....	1,426.50	1,349.00	940.00	2,903.00	1,654.62	5.3	.....	306.86	69.55	159.55	594.75	282.68	11.5
June	.....	.....	.....	263.50	.....	65.88	0.2	.....	.....	.....	16.90	.....	4.22	0.2
July	.....	.....	31.00	20.00	.....	12.75	.....	.....	9.50	20.15	37.14	.....	16.70	0.7
August	18.00	.....	49.00	210.00	.....	69.25	0.2	.....	.....	24.50	58.55	.....	20.76	0.9
September	5.00	.....	.....	232.50	.....	59.37	0.2	.....	.....	.....	47.45	.....	11.86	0.5
October	824.00	1,225.00	6,281.00	200.00	.....	2,132.50	6.8	169.43	66.95	566.59	7.00	.....	202.49	8.3
November	7252.00	216.50	15,589.50	75.75	.....	5,783.44	18.5	857.89	107.57	1,089.56	28.35	.....	520.84	21.3
December	.....	5.00	1,662.00	1,833.00	.....	875.00	2.8	6.00	6.70	67.50	232.28	.....	78.12	3.2
Totals	$8099.00	30,100.50	31,217.00	50,563.25	5,493.50	$31,368.32	100.0	$1,033.32	$1,517.45	$2,649.09	$3,510.57	$1,088.27	$2,449.67	100.0

*Fiscal year, July, 1925 to June, 1926, inclusive=131 fires, or 22 percent of total.
†Average to nearest unit.
‡For fiscal year July, 1925 to June, 1926, inclusive, 3,788 acres, or 7 percent.
Total area burned in four years 52,584¼ acres. Average area per spring=8,343. Average area per fall=4,802.

a 4-acre fire as it does to extinguish a 1-acre fire (provided they are nearly square or circular in outline). It should be appreciated also, that in fighting large fires it is usually necessary to make certain sacrifices in order to shorten the work. Quite frequently also, more advantage can be taken of the topography and of barriers such as roads and trails in fighting large fires.

On considering the figures in Table 42 it must be admitted that the average size of the fires has been much too large. Substantial reductions in area burned should be expected with the perfection of the organization, subject of course to seasonal variations.

TABLE 42.—Summary of Forest Fires in Ohio Fire District, by Fiscal Years, Beginning July 1

Fiscal year	Number of fires	Percent of 4-year total	Acres burned	Acres per fire	Percent
1922—23	133	22	16,933	127	32
1923—24	84	14	2,932	35	6
1924—25	248	42	28,931	117	55
1925—26	131	22	3,788	29	7
Total	596	100	52,584	88	100

Fiscal year	Damage to woods	Percent	Cost of suppression	Percent	Cost per fire	Cost per acre (8÷3) Cents
1922—28	$36,753.00	29.3	$2,360.05	24.1	$17.74	13.9
1923—24	9,051.00	7.2	1,071.51	10.9	12.76	36.5
1924—25	71,604.50	57.0	4,868.10	49.7	19.63	16.8
1925—26	8,064.75	6.5	1,499.04	15.3	11.44	39.6
Total	$125,473.25	100.0	$9,798.70	100.0	$16.44	18.6

NUMBER AND EXTENT OF FOREST FIRES ACCORDING TO THEIR CAUSE

The diagram (Fig. 22) shows under "Number" the relative frequency of forest fires from different causes for the fiscal year from July 1925 to June 1926, inclusive. Under "Area" is shown the relative area burned over by fires from each cause for the same period. It will be seen that while more than a third of the forest fires were started by railroads and brushburning, the area covered by these fires was relatively small. The large area under "miscellaneous" is due principally to one large fire reported to have started from a moonshine still. Fires of unknown origin would with more information be traced to either campers, smokers, or incendiaries in the majority of cases. Fires from these three classes undoubtedly do most of the damage.

For more detailed information as to the relationship of area of woods burned and the causes of fires, see Table 43.

TABLE 43.—Correlation of Causes of Fires and Area Burned For the Fiscal Year 1925-26

Cause	Number of fires	Percent	Area burned	% of area per cause	Average area per fire
Railroads	17	13.0	194¼	5.4	11.4
Logging	1	0.8	35	0.9	35.0
Brush burning	32	24.4	423	11.8	13.2
Campers	19	14.5	713	20.0	37.5
Smokers	9	6.8	81½	2.3	9.1
Incendiary	11	8.4	335	9.4	30.5
Miscellaneous	8	6.1	915½	25.6	114.4
Unknown	34	26.0	882½	24.6	26.0
Total	131	100.0	3579¾	100.0	27.3

THE FARM WOODS

Grazing is the most serious problem affecting the farm woods of Ohio. Over 65 percent of the 2,827,409 acres of farm woods in the State are pastured, usually thruout the entire year.

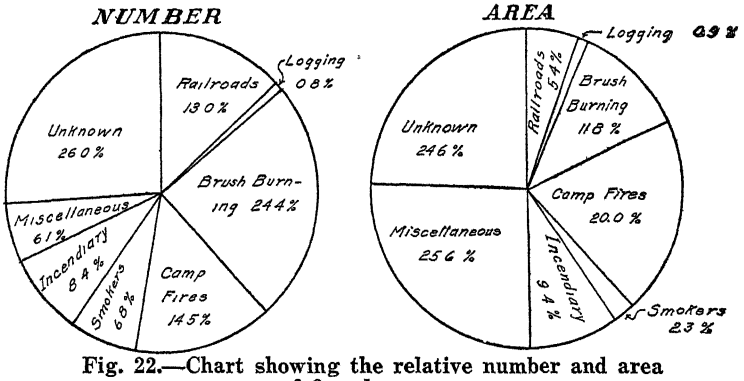


Fig. 22.—Chart showing the relative number and area of fires by causes

The average pastured farm woods is in a very run-down condition in respect to its future timber producing capacity. This is characterized chiefly by the almost total absence of all younger age classes. Too many of the farm woods look like parks instead of forest land. The ideal farm woods contains trees of all sizes and ages, and the forest floor is covered with a thick layer of leaves, instead of grass. The leaves form a mulch that helps to conserve the moisture which is so necessary for tree life. When a large tree is cut in such a stand there is always another tree ready to take its place in the succeeding years. In the pastured woods, when a tree

is cut or dies, there is nothing to take its place. As fast as young seedlings develop on the forest floor they are removed by the livestock.

In order to determine more definitely the limiting effect which pasturing has on the future lumber supply of the State, an intensive study of the grazing problem in its relation to the farm woods was begun this year. The object of the study is to illustrate the difference in the general composition, rates of growth and volume, and the grade of lumber and other products produced on pastured and unpastured woods. The study will also afford an opportunity for determining the best methods for quickly establishing ideal forest conditions on formerly pastured woods.

Several deductions can already be made from the data collected during the preliminary study of this season. When livestock are excluded from a previously pastured woods, a good stand of reproduction, composed of good species, usually will develop in from 5 to 10 years.

Table 44 indicates the composition of a typical northern Ohio woods nine years after livestock were excluded from the area.

TABLE 44.—Young Trees Per Acre After 9 Years' Protection

Species	Height in feet				Total per acre
	1	3	5	8	
	No.	*No.*	*No.*	*No.*	*No.*
Sugar maple	23,936	6,736	2,284	438	33,394
White ash	5,304	328	.....	.....	5,632
Basswood	216	.....	.....	.....	216
Ironwood	9,684	.....	.....	.....	9,684
Shadbush	4	108	.....	.....	112
Beech	802	39	.....	.....	841
Total	39,946	7,211	2,284	438	49,879

There were 76 large trees on this area, as follows: sugar maple, 63 percent; beech, 10 percent; white ash, 11 percent; basswood, 11 percent; and cucumber, 5 percent. These trees had an average diameter at 4½ feet of 14.9 inches, and an average height of 80.1 feet. No mature weed trees were found on the area. Ideal forest conditions have been established in this stand.

The average pastured farm woods usually contains a considerable number of large ironwood, blue beech, and dogwood trees. That weed trees, especially dogwood, can prevent the development of a stand of young trees, composed of better species, was also indicated by the preliminary study.

Table 45 gives the composition of an oak woods from which livestock have been excluded for a period of 30 years.

TABLE 45.—Trees in an Oak Woods From Which Livestock Have Been Excluded For Thirty Years. Per Acre

Species	Small trees					Large trees			Dead trees	
	Height in feet				Total					
	1 No.	5 No.	10 No.	15 No.	No.	No.	Average D. B. H.* In.	Average height Ft.	No.	Height Ft.
White oak	2168†	56	88		2,312	88	10.2	59	232	5.2
Black oak	448†	8		8	464	48	12.8	66	112	5.3
White ash		8			8	8	2.8	25		
Cherry	8	112	88	16	224	64	2.4	20	200	6.7
Walnut	8				8					
Hickory	8				8					
Red maple	8				8					
Hard maple									24	4.0
Ironwood	48	40	8		96	8	2.6	22	64	5.4
Blue beech				8	8				16	8.5
Dogwood	4	35	21	18	78	160	2.4	20	160	4.7
Aspen									8	14.0
Total	2,700	259	205	50	3,214	376			816	

*Diameter at 4½ feet above ground. D. B. H.=Diameter breast high.
†One year seedlings.

There were 160 large dogwood trees in the stand. These trees with their wide spreading crowns formed most of the shade on the forest floor. The dead trees on the area represent several generations of young seedlings which had developed on the forest floor, but were gradually killed by the dense shade from the dogwoods.

A liberation cutting which removed all of the dogwood, blue beech, and ironwood was made on the area for the purpose of determining whether this treatment would enable the present stand of seedling oaks to develop and form the future understory. The study serves to indicate the necessity of removing all weed trees from a pastured woods before livestock are excluded from the area.

FOREST TAXATION

The law providing for the classification of forest lands for purposes of taxation has been in operation since July 1, 1925. It provides for the reduction of the tax rate by 50 percent on farm woods and forests, which have been listed under the rules and regulations provided for the purpose. The law was designed for the purpose of encouraging timber growing by the private owner of land. It was intended to apply to forest land so located and containing such quality and condition of growth as would warrant its continuous use for successive timber crops.

The tax reduction law applies to land in native forest as well as that which is planted with trees and maintained for the production of timber crops. The law was never intended to apply to tracts of land in forest near the environs of cities, where the bare land itself has high value for purposes other than agriculture or forestry. Forests on property under such conditions are maintained more for the landscape effect than for timber production.

The law needs to be amended in a few respects in the light of experience obtained during the past year in its operation. On the whole, it should operate satisfactorily. The owner of a productive forest is entitled to tax leniency on such property, because of the period required to bring forest crops to maturity and the attendant risks from destruction by fire and insect and disease scourges. The Ohio law makes it possible to remove all taxes on the timber itself, and reduces the rate of taxation on the bare land by 50 percent. The nominal excise tax of 5 percent on the timber stumpage when cut is entirely just, and of course is applied only after the owner markets the timber.

Every owner classifying forest land under the Tax Law will automatically increase the timber yield from such land, as a result

of good management which is itself a condition of classification. No attempts have been made during the period since the law has been in effect to encourage owners to classify forest lands. Applications have been received from forest owners and classifications have been made by the State Forester.

It is believed that after the law is clarified by amendment its operation can be quite generally extended, and that it will result in a material increase in good forest practice in Ohio.

THE OPERATION OF THE FOREST TAX LAW FOR THE YEAR JULY 1, 1925 TO JUNE 30, 1926

	Number	Acres
Areas classified	42	6428.75
Areas examined but not classified	21	4314
Areas to be examined	26	2165
Total	89	12907.75

OHIO WEATHER FOR THE YEAR 1925

Perhaps the most outstanding features of the weather in Ohio during the year 1925 were: (1) A persistent deficiency in the precipitation during the first six months, reappearing in August; (2) marked fluctuations in the daily mean temperatures during a large part of the year, notably from about the middle of January to the middle of June, and again in October and December; (3) a great range (126°) in the temperatures for the year; (4) an abnormal amount of sunshine during the first six months, especially in April, the total accumulated excess for the six months being 48 percent; (5) more precipitation during the night than during the day in March, April, May, and August, and more during the daytime than at night during June and July; (6) an unusually fortuitous combination and distribution, both geographically and chronologically, of the major climatic elements; and (7) a complete absence of all climatic misfortunes.

The precipitation deficiency tho quite pronounced was not quite general over the State, some six or seven stations in the western half of the southern section and two or three in the extreme northwestern counties showing a slight excess; the deficiency was somewhat more pronounced in the Maumee Valley, in the counties just south of the "divide" and in the upper Muskingum Valley. The snowfall averaged about 65 percent of the normal, by far the greater portion falling in northeastern counties.

Hastily passing the months in review, we find: *January*—fine, seasonable weather during the first and second decades, very changeable with two cold waves during the third decade; precipitation generally deficient but snowfall slightly above the normal; *February*—abnormally warm with wide range in temperature, there being two well-defined and very pronounced warm spells of considerable length; precipitation about normal, most of it falling during the last week; quite a number of thunderstorms, some rather violent; *March*—on the whole, moderate, tho considerable range of temperature; precipitation well distributed thru the month but quite deficient in the middle and southern sections; about one-third the normal snowfall; *April*—unprecedentedly warm 22d to 26th, mild rest of month; precipitation deficient; severe local storms on 19th; *May*—persistently cool, notably so 24th to 27th when heavy to killing frosts occurred; severe local storms on 16th; *June*—warm, especially first six days; dry first

half, local thundershowers latter half, severe in places, as at Niles and Lancaster; *July*—cool, cloudy, humid and showery with large number of thunderstorms; *August*—about normal temperatures; daily thundershowers during first two weeks, no rain of consequence thereafter; severe hailstorm in Hocking County; *September*—delightfully warm; precipitation above average; severe droughty conditions in many localities; *October*—coldest and cloudiest October of record; heaviest snowfall of record in October; *November*—temperature variable early part, about normal latter part; precipitation above normal but snowfall less than usual; *December*—driest December since 1817; mild weather, generally favorable to outdoor operations, up to 25th when a cold wave accompanied by heavy snows overspread the State; total snowfall for the month, less than one-half the normal amount; considerable cloudiness.

The highest temperature for the year, 103°, was recorded at Hamilton on July 2; and the lowest, —23°, at Lancaster and Summerfield on January 28, giving an annual range of 126°. The highest annual mean, 56.2°, was recorded at Portmouth and the lowest, 48.0°, at Millport. The last killing frost in the spring occurred at most stations on or about May 25 and the first killing frost in the autumn occurred generally on October 10, thus giving a growing season of about 138 days.

The greatest amount of precipitation for the year, 54.71 inches, was recorded at Kings Mills, Warren County, and the least, 23.52 inches, at Sandusky, Erie County. The greatest monthly amount was 10.53 inches at Cincinnati in July and the least was 0.35 inch at Wapakoneta in December. The average snowfall for the year was 22.0 inches which is 11.7 inches below the normal. The greatest local annual amount was 61.6 inches at Warren, Trumbull County, and the greatest local monthly amount was 24.6 inches at Cadiz, Harrison County, in January. The average number of days with 0.01 inch or more of precipitation was 115; the average number of clear days was 144, partly cloudy days, 100, and cloudy days, 121. The prevailing direction of the wind was southwest.

WEATHER AT WOOSTER IN 1925

The mean temperature at the Station for the year 1925 was 49.8°, as compared with the 38-year average of 49.4°. The highest record for the year was 97° June 5, the lowest —9° December 30.

The total precipitation was 30.4 inches, or 8.7 inches below the 38-year average. The snowfall (unmelted) was 25.75 inches.

There were 122 days with a rainfall of .01 inch or more; 160 clear days; 51 partly cloudy; and 154 cloudy.

The growing season between the last spring frost May 27 and the first autumn frost October 10, was 136 days. The normal growing season at this Station is about 149 days.

The temperature for *January* was below the average. The precipitation was also deficient and mostly in the form of snow, some of which remained on the ground the entire month, the total snowfall for the month being 12 inches.

The temperature in *February,* with the exception of a drop on the 3d and again on the 27th and 28th, was very mild and has not been equalled at this Station for 35 years. The precipitation was below the average.

The temperature for *March* as a whole was well above the average; with a real warm period from the 24th to the 27th, when the mercury climbed to 76°. A severe blizzard occurred on the 19th and 20th, with no serious damage.

In *April* the mean temperature was above the average. The highest recorded for the month was 90° on the 24th. This high temperature has been surpassed but once in April at this Station in 38 years; this was on the 30th, 1894, when it registered 92°.

Thruout *May* the temperature was very changeable, ranging from 90° on the 23d to 30° on the 25th. A light snow occurred on the 24th and a heavy frost on the 27th; the many light to heavy frosts did much damage the latter part of the month. Rain or snow fell on fifteen days.

The average temperature for *June* was 72°, 4.6° above the 38-year average for this month; in only one year of the 38 (1919) was the average higher. The highest temperature for the month was 97° on the 5th. This high record has been surpassed but once (1895) in the history of the Station; the lowest temperature was 42°. The rainfall was light.

The temperature for *July* was slightly below the average; the precipitation 4.09 inches, was very near the average.

Some rain fell on eleven days of *August;* however, the total amount for the month was only 1.88 inches. A severe electrical storm occurred on the 5th. The mean temperature for the month was above the average. The highest was 95° on the 30th.

The rainfall for *September* was .84 inch above the normal; the temperature was 4.1° above normal, the highest being 95° on the 11th.

October was the coldest since 1895, the temperature ranging from 76° on the 1st to 18° on the 29th, with an average of 44.4°. Rain or snow fell on twenty-three days; the total snowfall for the month was 6 inches.

The weather for *November* as a rule was cold and cloudy, with precipitation above the average. The snowfall was light. The temperature ranged from 61° on the 8th to 17° on the 29th.

December was generally cloudy, and the precipitation light. The total snowfall was 2.75 inches, mostly near the end of the month, leaving the ground bare the greater part of the time. A severe cold spell occurred during the last week, the temperature registering —9° on the 30th.

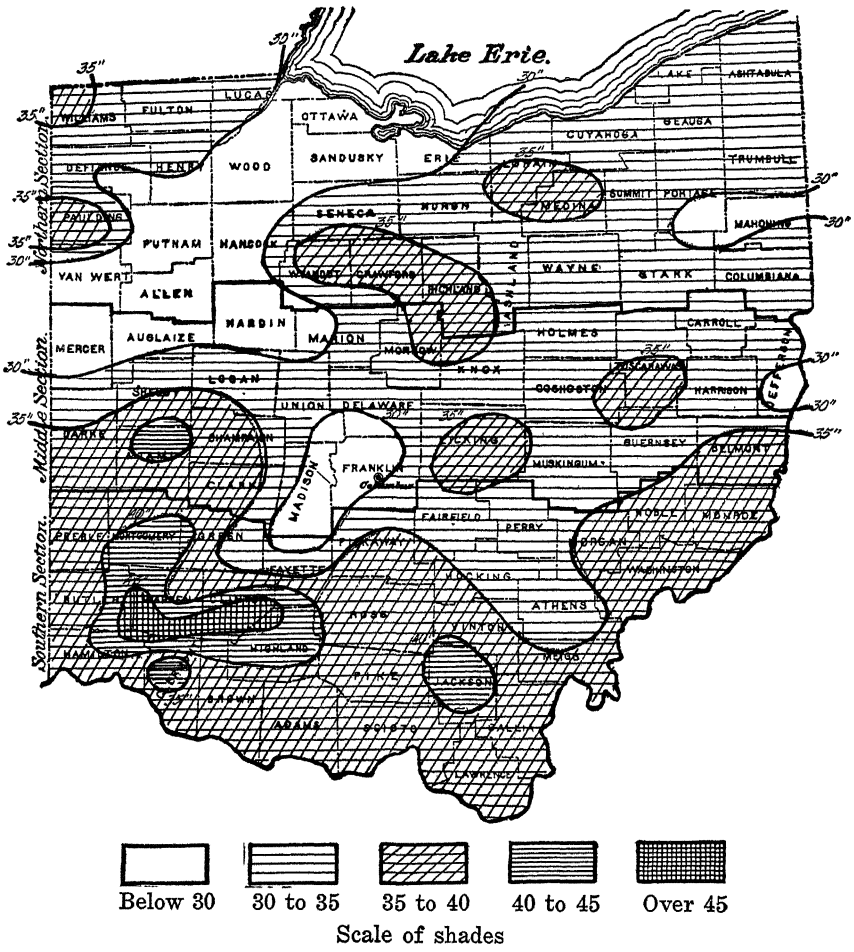


Fig. 23.—Precipitation in inches for the year, 1925

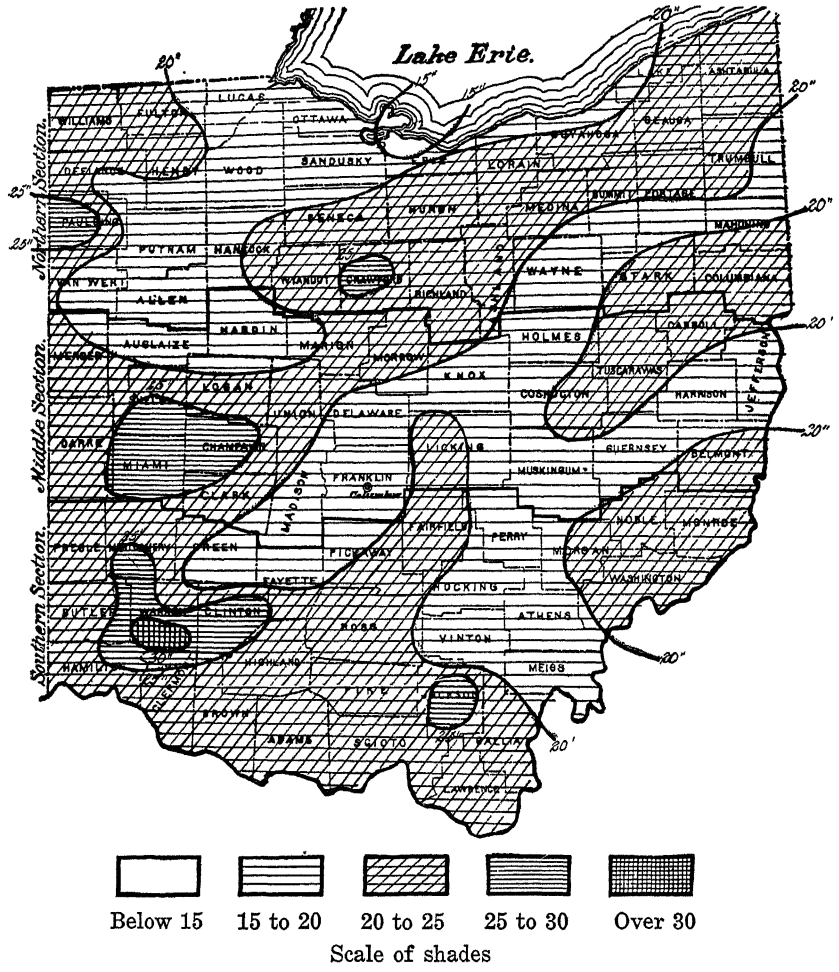


Fig. 24.—Total rainfall in inches during the growing season, March to September, inclusive, 1925

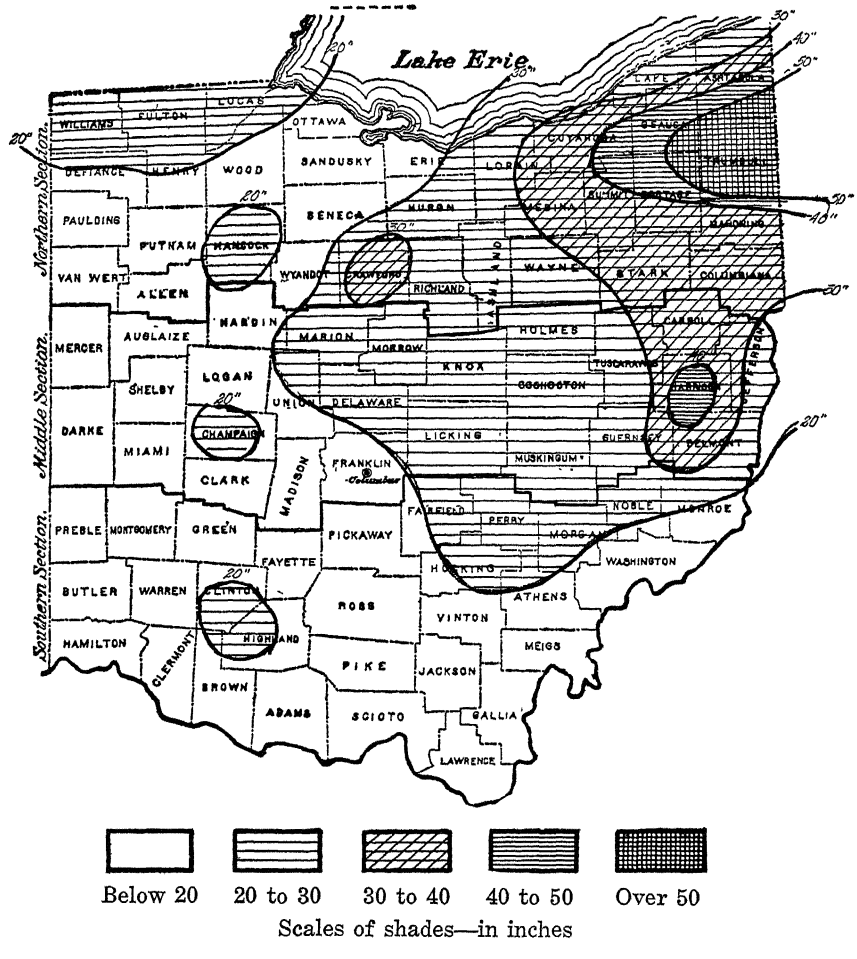


Fig. 25.—Total snowfall in inches for the year, 1925

TABLE 46.—Daily Rainfall and Melted Snow in Inches at Experiment Station, 1925

Date	January	February	March	April	May	June	July	August	September	October	November	December	Date
1			.20		.03							.02	1
2	.20	.10	T				T			.04			2
3	T				.02				.52	T			3
4			.20		.48		.18			.58			4
5			T		.06		T	.25		.02	.13	.59	5
6					.12	T	T		.05	.08	T	.02	6
7	T				.02	.01	T	.02	.35	.04	.80	T	7
8	.35							.13			.26		8
9		.19	.01			T		.82		.28	T	.02	9
10			.02	T	.73		2.65	.07		.06		T	10
11		.42	.40	.05	T		T						11
12	.05	.07		T			T	.32	.88	.12	.62	T	12
13	T	T	T					.15	.96	T	.14		13
14	T		.67	.78		.04					T		14
15			T	.47					.65	.13	.06		15
16	.38				.19	.09	T		T	.27	T		16
17	T		.02	T	.05	.57	.01			.30	.03	.02	17
18			.22	.01								T	18
19			.53	T				.10		T	.05		19
20	.40						.03	.01		T		.05	20
21		.15			T		.01	.01	.02	T		.02	21
22		.05				T	.26			.12	T	T	22
23		.88			.01	T					T	T	23
24		.03			.62	.29				.39	T	T	24
25		.11		T	.02	.29	.16			.24	.12	.20	25
26	.03	.10		.12		T	.25			.02			26
27	.05	T	.14			.03	T		.61	T	1.32		27
28		T	.07						.02	.14	T	T	28
29	.30		.02	.08	T	.92			.02				29
30	.05		T	.36						.18			30
31							.54	T					31
Total	1.81	2.10	2.50	1.87	2.35	2.24	4.09	1.88	4.08	3.01	3.53	.94	(Year) 30.40

TABLE 47.—A Climatological Summary for Each Month, for the State and Wooster, 1925

Month	Temperature								Precipitation			Number of days			
	Monthly mean	Departure from normal	Highest	Date	Lowest	Date	Range	Greatest daily range	Average	Departure from normal	Average snowfall	With precipitation .01 inch or more	Clear	Part cloudy	Cloudy
State															
	(a)								(b)						
January	27.2	—1.3	67	7	—23	28	90	50	1.69	—1.41	11.5	9	10	6	15
February	36.3	+7.8	76	8	—5	2	81	44	2.25	—0.17	1.8	9	11	7	10
March	41.8	+2.3	81	26	—7	3	88	52	2.63	—0.85	1.3	10	13	8	10
April	54.2	+4.2	97	24	21	6	76	55	2.04	—1.23	T	9	15	8	7
May	55.6	—5.2	95	23	26	25	69	53	2.61	—1.11	T	9	14	9	8
June	73.0	+3.6	102	5*	37	11	65	47	2.85	—0.98	.....	10	15	10	5
July	72.0	—1.7	103	2	39	1	64	46	4.69	+0.89	.....	12	13	12	6
August	72.0	+0.3	101	30	40	22*	61	51	2.34	—1.12	.. ...	8	17	9	5
September	70.1	+4.6	101	9	36	22	65	54	3.76	+0.90	.....	9	12	10	8
October	46.3	—7.7	83	1	11	29	72	34	4.37	+1.71	4.0	15	4	8	19
November	39.6	—2.0	69	8	10	9	59	41	4.06	+1.42	0.6	9	11	6	13
December	29.0	—2.2	64	4*	—11	30	75	40	0.82	—2.08	2.6	6	9	7	15
The year	51.4	+0.2	103	July 2	—23	Jan. 28	126	55	4.11	—4.03	22.0	115	144	100	121
Wooster															
January	25.7	—1.5	43	24*	—7	28	50	42	1.81	—1.39	12.00	9	11	2	18
February	35.6	+8.6	66	8	3	28	63	30	2.10	—0.40	2.00	10	14	1	13
March	40.2	+2.6	76	26	1	3	75	40	2.50	—1.05	2.50	12	11	8	12
April	52.0	+3.5	90	24	24	6	66	46	1.87	—1.18	.....	7	16	4	10
May	53.6	—4.5	90	23	29	12	61	44	2.35	—1.59	T	12	17	1	13
June	72.0	+4.3	97	5	42	11	55	39	2.24	—1.76	.....	8	23	3	5
July	70.4	—1.0	94	9	41	1	53	38	4.09	—0.01	.....	9	11	15	5
August	70.4	+0.7	95	30	42	22	53	43	1.88	—1.67	.....	10	22	6	3
September	67.8	+3.9	95	11	42	26	53	40	4.08	+0.81	.....	10	17	4	9
October	44.4	—7.3	76	1	18	29	58	31	3.01	+0.45	6.00	17	6	0	25
November	38.0	—1.9	61	8*	17	29	44	31	3.53	+0.86	0.50	10	9	3	18
December	27.5	—2.7	57	5	—9	30	66	31	0.94	—1.80	2.75	8	3	4	24
The year	49.8	.....	97	June 5	—9	Dec. 30	106	46	30.40	—8.70	25.75	122	160	51	154

*On other dates also.
(a) Based on reports from 85 or more well-distributed stations. (b) Based on reports from 83 or more well-distributed stations.

TABLE 48.—Temperature and Precipitation for the State and for Wooster

Year	State					Wooster				
	Temperature			Precipitation		Temperature			Precipitation	
	Mean	Max.	Min.	Annual	Growing season*	Mean	Max.	Min.	Annual	Growing season*
1888	49.5	102	—15	39.64	24.55	47.4	92	—5	38.05	22.76
1889	51.1	100	—14	33.41	20.32	48.6	92	—6	39.87	24.30
1890	52.2	103	—4	50.33	30.97	49.7	95	1	52.69	33.22
1891	51.8	101	—5	38.61	21.73	49.0	99	0	38.48	20.76
1892	50.2	103	—27	37.16	27.26	48.0	98	—20	41.53	32.02
1893	50.0	102	—24	39.63	22.69	48.7	95	—9	40.58	21.10
1894	52.4	105	—27	29.75	17.66	50.6	98	—7	30.78	17.13
1895	50.0	106	—24	28.46	14.59	47.8	98	—6	30.91	17.66
1896	51.8	102	—18	39.58	30.22	49.3	93	—6	39.10	29.57
1897	51.5	113	—27	38.59	23.07	49.4	96	—18	36.76	21.55
1898	52.2	105	—20	43.78	26.61	50.4	96	—9	47.85	30.77
1899	51.5	107	—39	34.32	22.18	49.5	95	—21	32.93	21.42
1900	52.2	103	—20	32.82	19.71	50.7	95	—10	36.61	23.70
1901	50.2	109	—20	32.36	23.37	48.7	95	—11	35.89	27.23
1902	50.7	100	—17	37.58	26.45	49.5	97	—9	32.95	23.28
1903	50.5	104	—20	36.85	22.75	49.1	94	—9	40.44	26.38
1904	48.6	99	—30	36.19	24.69	47.1	92	—21	41.28	28.16
1905	50.0	100	—22	39.08	27.20	48.8	92	—12	42.93	33.30
1906	51.6	101	—23	36.88	24.28	50.7	92	—14	42.82	30.10
1907	49.6	98	—23	42.85	28.09	48.4	90	—14	40.00	24.91
1908	52.1	104	—22	34.10	23.62	51.0	95	—3	33.94	22.73
1909	50.9	97	—20	42.66	26.58	50.0	90	—11	44.22	28.43
1910	50.4	100	—25	36.03	19.01	49.2	94	—12	35.45	15.86
1911	52.6	107	—19	42.63	22.95	50.8	101	—11	47.15	28.28
1912	49.6	101	—37	37.82	27.82	47.8	93	—24	46.60	36.40
1913	52.3	105	—15	44.75	27.24	50.6	96	—2	51.18	32.03
1914	50.9	106	—24	35.41	21.36	49.2	95	—18	37.38	25.11
1915	50.8	99	—22	40.83	26.56	48.9	91	—13	42.06	28.88
1916	51.0	104	—18	37.24	23.22	48.9	99	—7	34 93	21.18
1917	47.9	103	—31	36.51	24.64	46.3	96	—18	31.82	20.56
1918	51.5	110	—28	36.54	22.89	50.5	105	—19	33.75	20.74
1919	52.3	106	—12	40.33	25.10	51.2	95	—4	43.08	30.52
1920	50.3	98	—11	37.49	26.90	49.1	93	—5	39.70	30.64
1921	54.6	103	2	42.97	26.83	53.3	96	9	41.90	27.85
1922	52.8	101	—20	37.04	27.11	51.3	96	—11	34.42	23.94
1923	51.4	100	—7	39.02	25.58	50.2	97	—1	36.30	20.73
1924	49.3	101	—20	37.34	26.48	48.0	95	—11	38.90	28.25
1925	51.4	103	—23	34.11	20.92	49.8	97	—9	30.40	19.01
Average	51.0	.....	....	37.91	24.29	52.4	....	.....	39.10	25.54

*March to September, inclusive.

TABLE 49.—Monthly Mean Temperature at Experiment Farms and for the State

Farm	January	February	March	April	May	June	July	August	September	October	November	December	Year
Wooster 1925	25.7	35.6	40.2	52.0	53.6	72.0	70.4	70.4	67.8	44.4	38 0	27.5	49.8
Average 38 years	27.2	27.0	37.6	48.5	58.1	67 7	71.4	69.7	63.9	51.7	39.9	30.2	49.4
Germantown 1925	29 3	39.2	44.0	56.6	56.9	74.2	73.4	72.7	72.0	47.2	40.8	30.0	53.0
Average 11	29.0	32.9	41.9	52.3	60.4	70 8	74.1	72.5	66.5	55.1	43.2	32.5	52.6
Batavia 1925	30.7	40.8	45.4	58.0	58.0	75.9	74.2	73.6	73.8	48.4	41.4	31.3	54.3
Average 10 years	30.1	33.7	44.4	53.4	61.8	72 0	74.9	73.9	67.5	56.2	43.8	34.0	54.9
Canfield 1925	23.4	32.6	39.0	50.9	52.8	70.1	69.2	69.6	65.9	42.6	36.5	27.4	48.3
Average 10 years	24.4	27.7	27.6	47.7	56.5	66.9	70.1	68.8	62.5	50.7	39.2	29.4	48.4
Marietta 1925	31.4	38.8	44.5	56.2	57.8	73.6	72.6	72.2	72.6	49.2	40.1	31.6	53 4
Average 10 years	31.0	33 7	43.8	52.7	61.3	71.0	73.9	73.0	66.0	54.6	42.3	34.1	53.2
Mt. Healthy 1925	30.5	40.2	45.0	57.4	56 7	73.9	73.8	72.9	73.4	48 4	43.0	29.9	53.8
Average 10 years	30.0	33.2	44.3	52.8	61.4	71.5	74.7	73.7	67.6	55.9	44.1	33.4	53.5
Paulding 1925	21.4	33.8	38.4	52.2	54.2	71.6	70.4	70.6	68.2	45.0	37.0	25.9	49.1
Average 10 years	24.3	27.4	38 7	48.6	58.1	69.2	72.8	71.5	65.2	52.2	39.9	29.0	49.6
State 1925	27.2	36.3	41.8	54.2	55.6	73.0	72.0	72.0	70.1	46.3	39.6	29.0	51.4
Average	28.5	28.5	39.5	50.0	60.8	69.4	73.7	71.7	65.5	54.0	41.6	31.2	51.2

TABLE 50.—Monthly Rainfall at Experiment Farms and for the State

Farm	January	February	March	April	May	June	July	August	September	October	November	December	Year
Wooster, 1925	1.81	2.10	2.50	1.87	2.35	2.24	4.09	1.88	4.08	3.01	3.53	0.94	30.40
Average, 38 years	3.20	2.50	3.55	3.05	3.94	4.00	4.10	3.55	3.27	2.56	2.67	2.74	39.10
Carpenter, 1925	3.00	2.75	2.39	2.76	3.40	1.66	5.34	2.09	1.57	5.88	4.39	1.01	36.24
Average, 20 years	3.79	2.59	3.57	3 24	3.74	3.93	3.61	3.17	2.22	2.84	2.28	3.02	38.02
Germantown, 1925	1.02	1.78	2.56	3.29	1.40	3.28	3.43	3.52	8.71	7.90	6.04	0.67	43.60
Average, 21 years	3.57	2.38	4.03	3.76	3.74	3.16	3.45	4.34	3.18	3.09	2.69	2.98	39.64
Strongsville, 1925	.95	2.73	2.82	1.65	2.82	3.04	4.15	1.96	6.82	3.95	2.91	0.97	34.77
Average, 26 years	2.69	1.97	3.14	3.28	3.62	3.24	3.83	3.70	3.33	2.76	2.62	2.77	39.18
Batavia, 1925	1.39	1.42	1.75	2.71	1.66	1.60	5.27	3.30	4.66	5.51	4.82	0.70	34.79
Average, 10 years	3.34	1.57	3.40	3.43	3.61	3.82	3.22	3.87	2.85	3.10	2.62	3.22	38.42
Canfield, 1925	1.49	2.10	2.49	1.07	2.48	4.36	5.16	1.74	4.45	3.90	3.33	0.90	33.47
Average, 10 years	2.22	1.46	2.54	3.12	3.80	4.09	3.61	2.59	3.42	2.73	2.53	2.25	34.49
Marietta, 1925	3.33	2.46	2.05	1.96	3.01	3.61	6.10	1.54	0.60	5.62	3.34	0.63	34.25
Average, 10 years	3.34	2.08	3.53	3.51	4.03	4.22	4.43	3.56	2.78	3.13	2.92	3.15	39.96
Mt. Healthy	1.27	2.24	2.32	2.39	2.85	2.25	8.52	3.33	3.48	4.80	5.90	0.73	40.08
Average, 10 years	3.49	1.96	4.46	3.70	3.65	3.69	3.77	3.82	3.29	3.20	2.97	3.50	40.43
Paulding, 1925	1.10	2.63	5.48	2.47	1.54	3.17	6.13	1.91	5.58	2.83	4.17	1.07	37.08
Average, 10 years	2.00	1.14	3.96	2.96	3.99	3.63	3.22	2.18	2.98	3.00	2.46	2.84	35.00
State, 1925	1.69	2.25	2.63	2.04	2.61	2.85	4.69	2.34	3.76	4.37	4.06	0.82	34.11
Average	3.10	2.42	3.48	3.27	3.72	3.83	3.80	3.46	2.86	2.66	2.64	2.90	38.14

TABLE 51.—Date of First and Last Killing Frost, Length of Growing Season, and Number of Days the Mercury Registered Zero or Below at the Experiment Station at Wooster Each Year

Year	Date of killing frost		Length of growing season, days	Number of days mercury registered zero or below				
	Last in spring	First in autumn		Jan.	Feb.	March	Dec.	Total
1894	April 13	October 7	177	.....	2	.....	2	4
1895	May 22	September 28	129	5	7	.....	2	14
1896	April 24	September 24	153	1	3	.....	.....	4
1897	May 26	September 21	118	4	.....	.....	.....	4
1898	May 9	October 16	160	1	3	.....	.....	4
1899	May 22	September 30	131	3	8	.....	2	13
1900	May 10	October 18	161	2	5	1	.....	8
1901	May 16	October 2	139	2	1	1	4	8
1902	April 28	September 16	141	.....	5	.....	1	6
1903	May 4	October 23	172	3	3	.....	6	12
1904	April 20	September 22	155	7	8	.....	1	16
1905	May 4	October 13	142	3	10	.....	.....	13
1906	May 10	October 11	154	.....	6	1	.....	7
1907	May 12	October 14	155	5	3	.....	.....	8
1908	April 17	September 30	166	.....	1	.....	.....	1
1909	May 12	October 19	160	1	1	.....	1	3
1910	May 15	October 29	167	3	6	.....	1	10
1911	May 5	October 24	172	1	.....	.....	.....	1
1912	June 8	September 30	114	12	7	.....	.....	19
1913	June 10	September 23	105	.....	1	.....	.....	1
1914	May 2	October 27	178	1	6	.....	5	12
1915	May 27	October 10	136	4	1	.....	.....	5
1916	April 28	September 19	144	2	1	1	5	8
1917	May 11	October 1	143	2	8	.....	9	19
1918	May 2	October 1	152	8	4	.....	.....	12
1919	April 27	October 13	169	.....	.....	.....	2	2
1920	May 16	October 7	144	4	1	.....	.....	5
1921	May 17	October 13	149	.....	.....	.....	.....	0
1922	May 1	September 26	148	4	1	.....	1	6
1923	May 10	September 14	127	.....	1	.....	.....	1
1924	April 23	October 23	183	6	.....	.....	4	10
1925	May 27	October 10	136	2	0	0	3	5
Av.	May 9	October 9	149	86	103	4	49	241

REPORT OF THE BURSAR

1925-1926

CONSOLIDATED STATEMENT

ASSETS AND LIABILITIES

ASSETS

Current Assets	$ 253,392.44	
Land	320,331.68	
Land Improvements	38,929.73	
Buildings	458,970.62	
Departmental Equipment	276,575.30	
Total Assets		$1,348,199.77

LIABILITIES

Capital Account	$1,118,260.46	
Special State Appropriation	229,939.31	
Total Liabilities		$1,348,199.77

INCOME AND EXPENDITURES

INCOME

Cash Balance July 1, 1925		$ 19,297.50	
Appropriations by Legislature	$569,248.03		
" by U. S. Government	54,024.72		
Sales of Produce, etc.	57,221.47		
Total Income		680,494.22	
Total			$ 699,791.72

EXPENDITURES

Salaries	$ 240,564.85	
Employees and Extra Labor	131,375.31	
Stationery and Office Supplies	2,823.35	
Incidentals	7,140.42	
Laboratory Supplies	5,523.99	
Materials and General Supplies	58,508.08	
Repairs to Equipment	6,142.67	
Telephone and Telegraph	1,349.70	
Freight and Cartage	6,371.82	
Travel	21,943.25	
Feed	30,419.41	
Fertilizers	856.41	
Apparatus	3,138.99	
Furniture and Fixtures	2,169.51	
Machinery, Tools, etc.	18,987.18	
Library	370.31	
Livestock	10,638,38	
Land	78,873.95	
Land Improvements	5,401.05	
Building Improvements	42.58	
New Buildings	43,697.38	
Total Expenditures		$ 676,338.59
Cash Balance June 30, 1926		$ 23,453.13